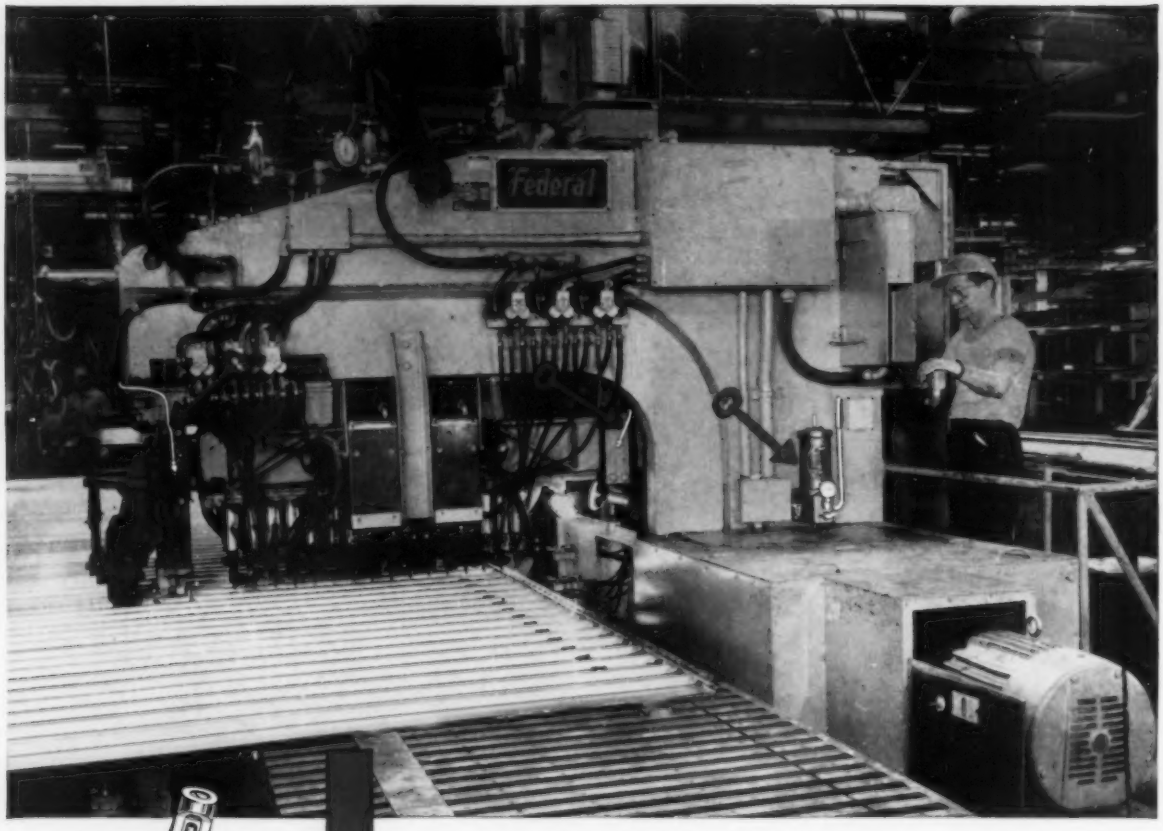
OCTOBER 27, 1958 Price 50 cents

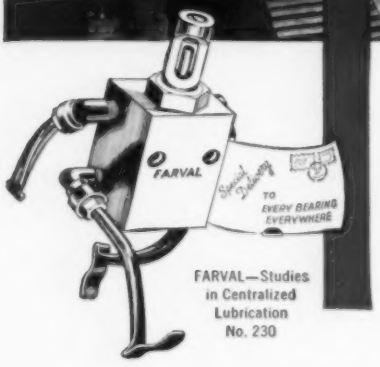
DESIGN issue

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

Satellite eyes earth's infrared ... page 5





FARVAL—Studies in Centralized Lubrication No. 230

Farval lubrication system protects bearings on Federal multi-gun welder

Resistance welders such as this multi-gun Federal, owe much of their effectiveness to their ability to adjust vertical movement of electrodes within exacting limits. Chosen to guard the essential bearings which give this Federal welder its precise control is a modern Farval lubrication system.

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Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval —familiar valve manifolds, dual lubricant lines and central pumping station—you know a machine is being properly lubricated.

FARVAL
CENTRALIZED SYSTEMS OF LUBRICATION

Riveting With a Hammer in Blind or Open Applications

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J. K. BARRY, M. E.

The use of blind rivets installed with only an ordinary hammer from one side of the job offers a highly simplified method of fastening. Speed, convenience and *low installed cost* make Drive Riveting preferable not only for blind joints, but for fastening many parts that can be reached from either side.

The Southco Drive Rivet has a cored, slotted body with a grooved pin protruding from its head. When the rivet is inserted through parts to be fastened, the pin is driven flush with the rivet head causing the expanding prongs to form a blind head behind the rear sheet. No further finishing is necessary, since the pin seats itself permanently to complete the smooth head contour.

Drive Riveting has five major advantages:

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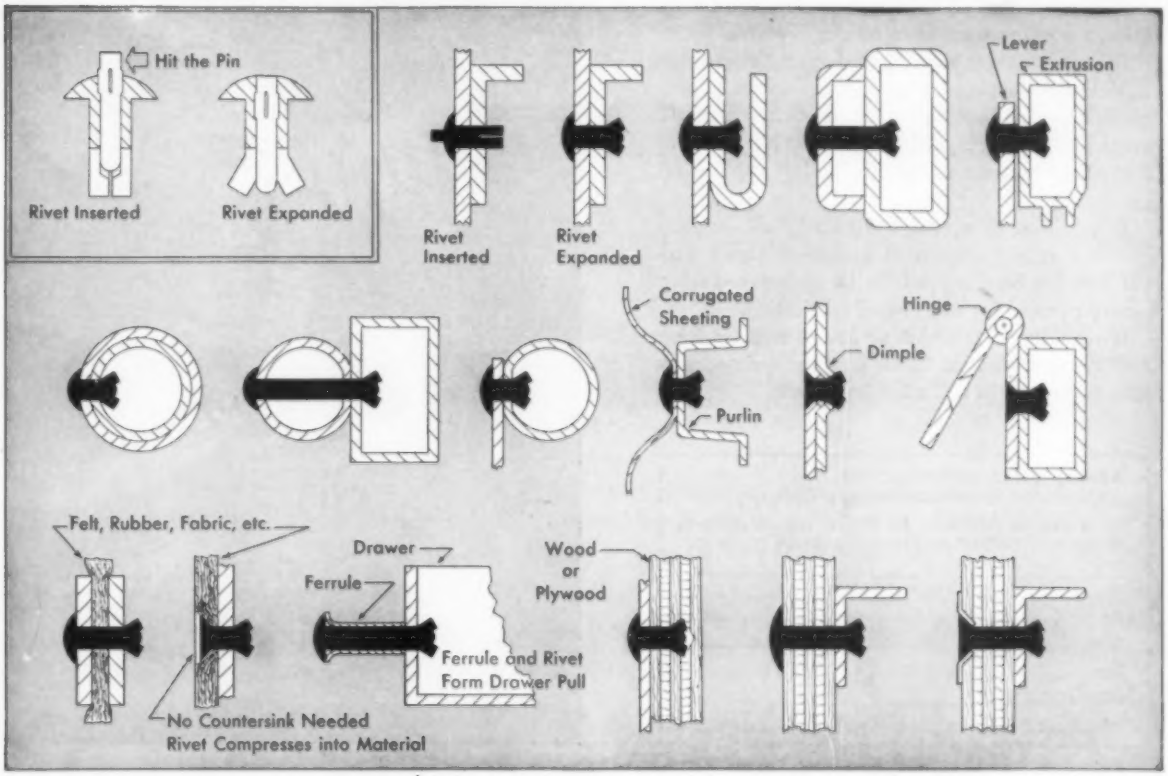
3. No limitation on the number of men who can install rivets.
4. Speed comparable to nailing.
5. Only one man is needed.

Widely used in truck bodies, storm doors, metal buildings and hundreds of other industrial applications, Southco Drive Rivets make a secure, vibration resistant joint. A wide range of head styles, diameters and grip lengths is available.

RECOMMENDED APPLICATIONS FOR DRIVE RIVETING



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Armco Stainless Steels

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Corrosion can play hob with proper functioning of springs. That's why the corrosion resistance and elastic properties of Armco Stainless Steels keep springs working even when service is severe.

Other advantages pay off, too. Each stainless grade in Armco's complete range of types offers its own combination of heat resistance, elasticity, strength, magnetic or non-magnetic properties. It's easier to find exact answers to specific spring application problems.

In addition to a complete variety of standard grades, special precipitation hardening Armco 17-7 PH Stainless Steel is available for springs requiring superior properties and ease of fabrication.

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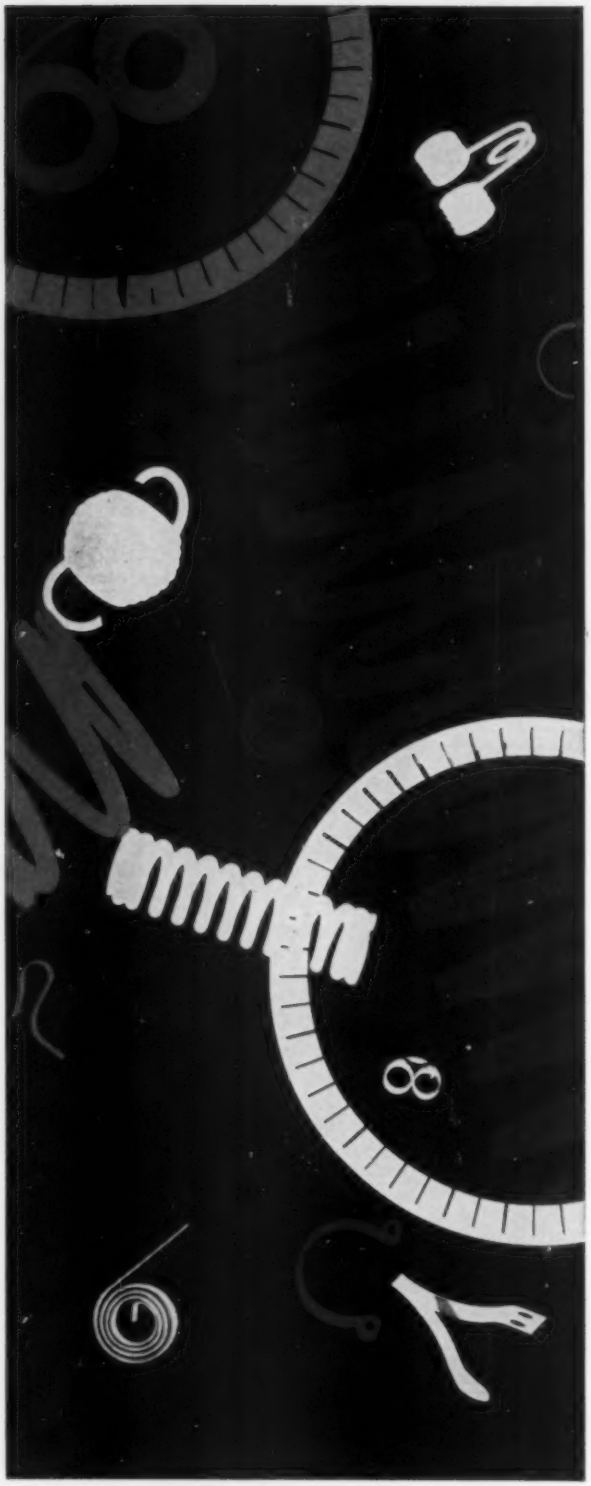

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

OCTOBER 27, 1958 Vol. 29, No. 44

* **Microfilm Pushes Drawings Aside** 44... W J Locke, Bell Telephone Laboratories
Overflowing files of engineering drawings boost costs and fight the engineering staff for working space. Here's how miniaturization can solve such problems—and save the engineer's time.

Closer Look at Metal Properties 48... Edward Loria, Crucible Steel Co of America
Working with metal often involves mechanical properties that seem hidden—but can be found right in the test data. The author gives 7 ways such study can remedy design troubles.

* **Numerical Control of Machine Tools** 50... Murray Rosenblatt and J. L. Dutcher, General Electric Co
Goodby to need for templets—or manual skill—when you exploit the advantages of punched tape and coded cards. Article gives ABC's of this modern way to boss automatic machine tools.

Finding Alternate 4-bar Linkages 54... R T Hinkle, Michigan State University
For every linkage there are two substitutes that provide the same desired motion. Author includes three examples showing how to apply Roberts' Law graphically for quick results.

Design Features in New Products 56... This weather reporter goes into orbit—by riding a satellite it will give cloud data on a world-wide scale; clocks now wound by heat; let's see what's new with Chevy.

Belts for Adjustable-pitch Pulleys 59... R G Prouty, Manheim Mfg and Belting Co
Link V-belts combine lateral stiffness and lengthwise flexibility with helpful vibration-absorbing characteristics.

DESIGN FILE

14 Adjusting Devices 62... Federico Strasser, Mankowitz & Strasser, Ltd
Basic arrangements that provide and hold mechanical adjustment.

Diameter for True Involute Form 65... E A Niemann, Minneapolis-Honeywell Regulator Co
Examples and chart for contouring 20° pressure-angle spur gears.

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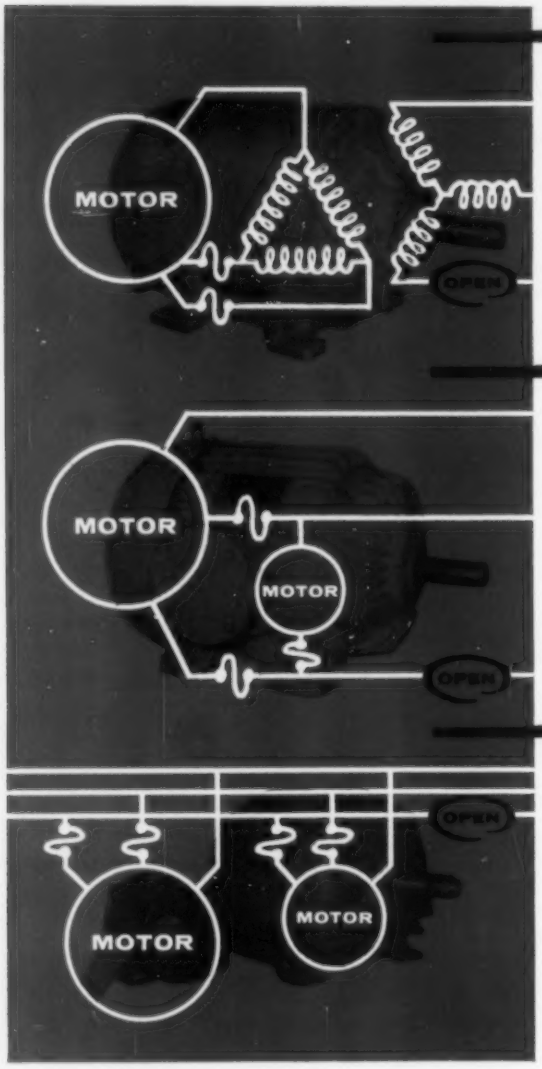
Three-Coil Overload Protection Would Have Prevented These Motor Burn-outs

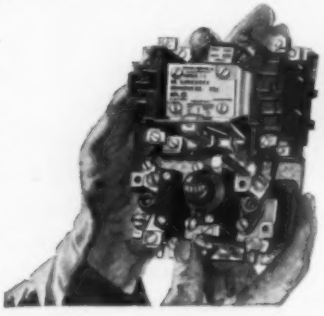


MOTOR No. 1. Even though this three-phase motor was equipped with a 2-coil overload relay, the motor burned out . . . and here's why. Like the vast majority of three-phase motors in use today, this motor took its power from a wye-delta transformer; and an open phase condition in the transformer primary caused one high and two low motor currents. The 2-coil overload relay could not save this motor because the high current was in the unprotected line. Why gamble with a motor burn-out? Insist upon 3-coil overload relays for all your three-phase motors . . . the only dependable overload protection for all open phase conditions.

MOTOR No. 2. This three-phase motor was operating at 70% full load with a 40% loaded single phase motor connected in parallel when one of the incoming power lines opened. Once again the 2-coil overload relay failed to detect any trouble. However the motor current in the winding without a thermal element rose to 152% full load current, while the current in the phases with the 2-element relay did not reach tripping value. This caused permanent damage to the motor winding. This motor could have been saved with full three-phase overload protection. Be sure your three-phase motors are completely protected from the hazards of all open phase conditions with dependable 3-coil overload relays.

MOTOR No. 3. This 1 Hp, three-phase motor was working in parallel with a 10 Hp, three-phase motor when one of the incoming power lines opened. While the 10 Hp motor was not adversely affected by this circuit unbalance, the motor current in one line of the 1 Hp motor reached 140% full load current resulting in a burned out winding. As in the other examples, the 1 Hp motor's 2-coil overload relay proved ineffective because the overload occurred in the one line left unprotected. Don't let this happen to your motors. Insist upon 3-coil overload relays for every three-phase motor, large or small . . . only 3-coil overload relays provide dependable open phase protection under all operating conditions.

Cutler-Hammer Three-Star Motor Control offers 3-coil overload relays in all standard starter constructions and enclosures. For immediate delivery see your nearby Authorized Cutler-Hammer Distributor. Machine designers and panelbuilders, open type Cutler-Hammer Three-Star Motor Control with 3-coil overload relays require no more space than starters with only 2-coil overload relays. For further information write Dept. U249, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.



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CONTROL
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Interesting to Note . . .

Satellite Eyes

Our Sidewinder roused the wrath of the Red Chinese a few weeks back. It utilizes infrared rays emitted from the heated exhaust of the foe plane, and homes with uncanny accuracy. Infrared can also be used to "see"—and map—through clouds, and may be in later applications of the device shown on our cover and described in detail on page 56. Made for the Signal Corps R & D Labs by Perkin-Elmer Corp, it will utilize a different cell to check weather—if Vanguard or Jupiter can put it in orbit. From an altitude of 200 miles, satellites containing such "eyes" could plot and map large cloud masses and storm centers, thereby giving a panorama of the world's weather-in-the-making.

Map making is one of our oldest sciences. On cave walls, anthropologists have found crude drawings showing where an animal was killed or how to find a certain lake. Maps were baked in clay by the Babylonians around 2500 BC. They were used to divide land into districts for purposes of taxation. During the time of Homer (900 BC), sketches were drawn portraying mythological islands in the Aegean Sea. The world was imagined to be a disk surrounded by a huge river, all being suspended under the sky.

Clay tablet from Ga-Sur (2500 BC)

European cartography during the Middle Ages was practically worthless. Since the official church doctrine ruled the world was flat, any thinking to the contrary was heresy. With more and more exploration, knowledge was gained that allowed map makers more accuracy. Now we have fathometers to aid in mapping land beneath the sea; and with a satellite's light-catching eye we will soon accurately map the world and the clouds above it. We will still have a long way to go—at present less than 25% of the earth's land area has been accurately mapped.

Colorful Job Titles

Now that planes are crisscrossing the Atlantic like shuttles across a loom, the once glamorous pilots of old have been reduced to "swamp jockeys." Perhaps the airline pilots who selected this

(Continued on page 7)

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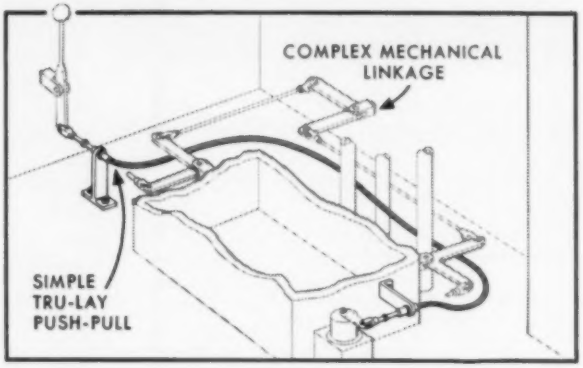

Here's Why Push-Pull Controls Simplify Design, Give Better Performance

Long Life—We have never heard of a Tru-Lay Push-Pull wearing out in normal service.

Dependable Operation—Top performance under the most adverse conditions...in temperatures ranging from −70°F to the high levels of jet engine operation...in wet locations...in abrasive atmospheres.

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Accuracy—Built to the most exact standards of quality and precision. On automobile pushbutton transmissions, for instance, Push-Pull controls provide five positions with a total movement of only .560".

Capacity—Push-Pull controls will handle jobs with as much as 1,000 lbs. input, 150 feet or more from the control point.

Adaptability—Push-Pull controls can be adapted to countless applications. Standard anchorages, fittings, and heads meet almost any requirement, and modifications can be made to fit special situations.

Design Engineers Report on Benefits

Saves Time, Labor, and Material
"We use Push-Pulls to operate clutch controls on the main power unit, feed conveyors, and delivery conveyors...and we save the time, labor, and material required for planning and engineering the old linkages."

Greater Flexibility of Design
"Push-Pulls give us flexibility in locating the hydraulic control valve in relation to the operator's position."

Cost Less to Install
"They are easier and less expensive to install than linkages for remote control of power take-off."

Solution to Tough Problem
"Can be installed where straight rods are impossible."

Eliminates Maintenance
"No maintenance whatsoever; not even lubrication is required."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods, and other lost-motion devices for remote control of hydraulic valves."

Provide Accurate Control
"We get minimum backlash because the cable is designed to close tolerances with minimum drag and lost motion."

Push-Pulls Can Help Solve YOUR Remote Control Problems

Push-Pull controls are solid as a rod and flexible as a wire rope. You can use them in the electrical, hydraulic, and pneumatic systems on construction equipment, on farm implements...almost *anywhere* convenient remote control is desired. For complete details on how you can use them, write for a copy of the Push-Pull Data File. It contains 7 bulletins which describe in detail the operation of Push-Pulls, their applications, features, and advantages. Our engineers will be glad to help you make Tru-Lay Push-Pull controls a part of your product.

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rather unglamorous title for themselves did so not to minimize their profession or responsibilities but because so many other industries have spawned strange job titles. The steel industry, for example, has its monkey man, its dresser, its skull cracker, its hanger, and many more.

The monkey man is no dull-witted simian-faced hood, On the contrary, he is a highly intelligent workman whose job is essential to the production of iron in the blast furnace. A dresser reshapes worn and damaged tools, and the skull cracker operates a crane that raises a five-ton ball and drops it on scrap metal to break it into smaller pieces. A hanger does just that; he hangs ready-to-paint steel fence posts on an overhead rack. Next time you see stainless specifications, like those on page 48, think of the steel mill menagerie responsible for putting out the finished product.

Time Out for a Sermon

"Brother, why is it that in winter your sermons are so much longer than in summer?" one monk asked another. "Simple, Brother," came the reply, "When the weather gets cold, the water in my clock gets as stiff and hard as a winter's lake and I have no way to time myself." A conversation of this sort actually took place around 1400, for shortly thereafter the monk who couldn't time his sermons in cold weather simply substituted sand for water and the hourglass was born.

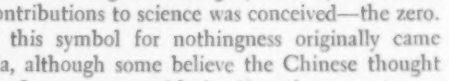
Telling time in the Middle Ages was far from accurate. The water clock, that era's most common timepiece, was somewhat like a milk bottle with a tiny hole drilled in the bottom—just enough to permit a slight drip. The sides of the container were crudely calibrated and time could be told by reading the mark to which the water had fallen. A variation was to make water drops fall on a miniature water wheel. One of the most interesting of these was built for the Arab monarch, Haroun Al-Raschid 1150 years ago. Using nothing more than drops of water, his clock told the hour on a clock face, rang a bell every hour, gave movements of the planets by means of a turntable and had an armored rider (a different one for each hour) spring out through a door each time the bell rang. As weird, but scientific in an ultramodern way, are the driving mechanisms for Swiss clocks, shown on p. 57.

However, the hourglass, still being used to regulate sermons in the 300-year-old church at Wiltshire, England, was only a stepping stone toward the mechanical clocks put in church towers to call the faithful to devotions. The very word "clock" originally meant "bell"—and the meaning is retained in the French word, cloche.

An atomic clock is already in existence. It's housed at the National Bureau of Standards and splits a second into 24 billion parts.

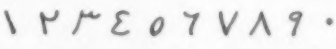
The Zero—Key to Calculation

Sometime between the death of King Solomon (932 BC) and the founding of Carthage (814 BC) one of the greatest contributions to science was conceived—the zero. Most say this symbol for nothingness originally came from India, although some believe the Chinese thought of it first. In any case, with its inception a vast new horizon was revealed. Man could do more than count; he could calculate. One of the first numeral systems incorporating the zero was Arabic and looked something like this:

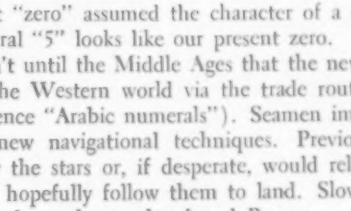


Note that "zero" assumed the character of a dot while the numeral "5" looks like our present zero.

It wasn't until the Middle Ages that the new concept reached the Western world via the trade routes of the Arabs (hence "Arabic numerals"). Seamen immediately adopted new navigational techniques. Previously they used only the stars or, if desperate, would release birds and then hopefully follow them to land. Slowly, bookkeepers and merchants abandoned Roman numerals. It wasn't an easy transition. Roman numerals continued in some schools until around 1600 and in commercial bookkeeping for another century. It was felt that they were easier to add and subtract than Arabic numbers. And, of course, it was a long haul before we reached the stage of Numerical Control (p. 50), which is frequently based on the "binary" system of numbers, where only 0 and 1 are used. A Spanish manuscript dated 976 lacked a zero. It looked like this:



Slowly the system evolved:



Writing large numbers, over a thousand, was extremely rare. Therefore the terms *million*, *billion* and *trillion* are relatively new. Until the seventeenth century the term "a thousand thousand" was used. In fact, it still is in certain parts of Europe. The Italians initiated the word "mille" meaning "a big thousand" as well as *bimillion*, which originally meant a million million. *Trillion*, *quadrillion*, etc., are contemporary.

—Benedict A. Leerburger Jr

A combined reprint including the series of articles on "Why Modernize," in the R & D Issue Oct. 6, and the series on "How to Modernize," Design Issue Oct 13, is now available. Copies may be obtained at 50c each, as long as the supply lasts, by writing Reader Service Manager, Product Engineering, 330 W 42nd St, NY 36. Ask for "Plan 59" reprint.

WHAT MATERIAL

DRY CHOCOLATE DISPENSER. To meet special qualities in esthetics and strength, BAKELITE TMDB-5161 is used in molding the precision main parts of the new "Carnation" hot cocoa mix dispensers for use in the restaurant field. The high heat-and-impact resistance of this styrene material makes it completely washable, and insures accurate, trouble-free service.

Molded by Field Manufacturing Corp., Santa Monica, Calif.

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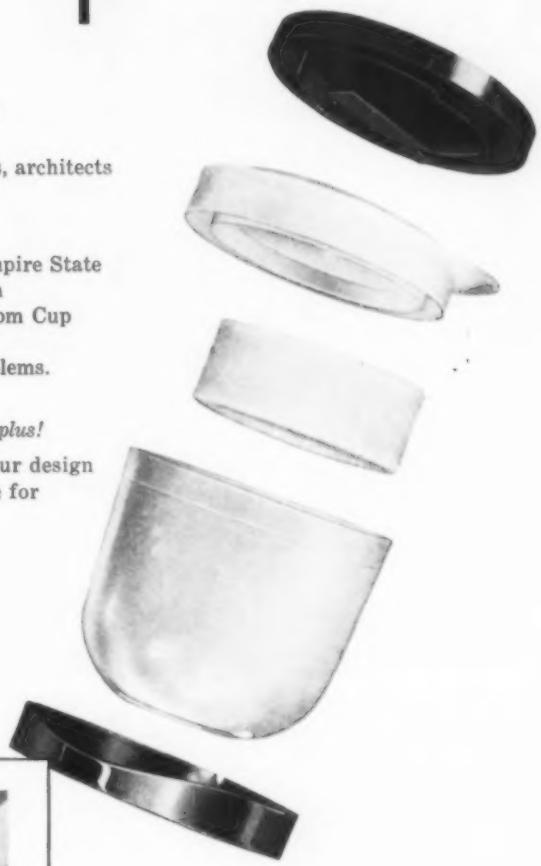
Technical representatives with years of training and field experience are available to discuss your special design problems. Write Dept. JX-51D.



THIS NEW AND DIFFERENT BLENDER, with separate compartments from which liquids are automatically mixed when poured, is easy to clean and hard to break. BAKELITE C-11 acrylonitrile-styrene-copolymer is used for the outer container, for strength, chemical resistance and low cost. The lid is BAKELITE Brand Styrene Plastic. Molded by Avsco, Inc., Excelsior Springs, Missouri.

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BAKELITE COMPANY, *Division of Union Carbide Corporation,* 30 East 42nd Street, New York 17, N. Y.

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key words in solving production puzzles:

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If one of your toughest production puzzles is getting top quality stainless steel *when* you need it, check in now with the Allegheny-Ryerson combination.

Allegheny Ludlum is the leading producer of stainless steels in all forms. And Ryerson, long recognized as the largest and best steel service center, carries Allegheny Stainless. This unbeatable team brings you the best quality stainless quick, when you need it.

Ryerson now stocks 2,351 shapes, sizes, finishes and alloys of Allegheny Stainless . . . the most complete line of stainless anywhere! And Ryerson relieves you of the inventory cost, gives you as quick service as your own stockroom.

Whether your order is for Allegheny Stainless sheet, plates, bars or whatever, Ryerson stocks it. Trained salesmen and technicians to help in selecting or in fabricating are at your service.

Call Ryerson, for top quality Allegheny Stainless from warehouse stocks. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

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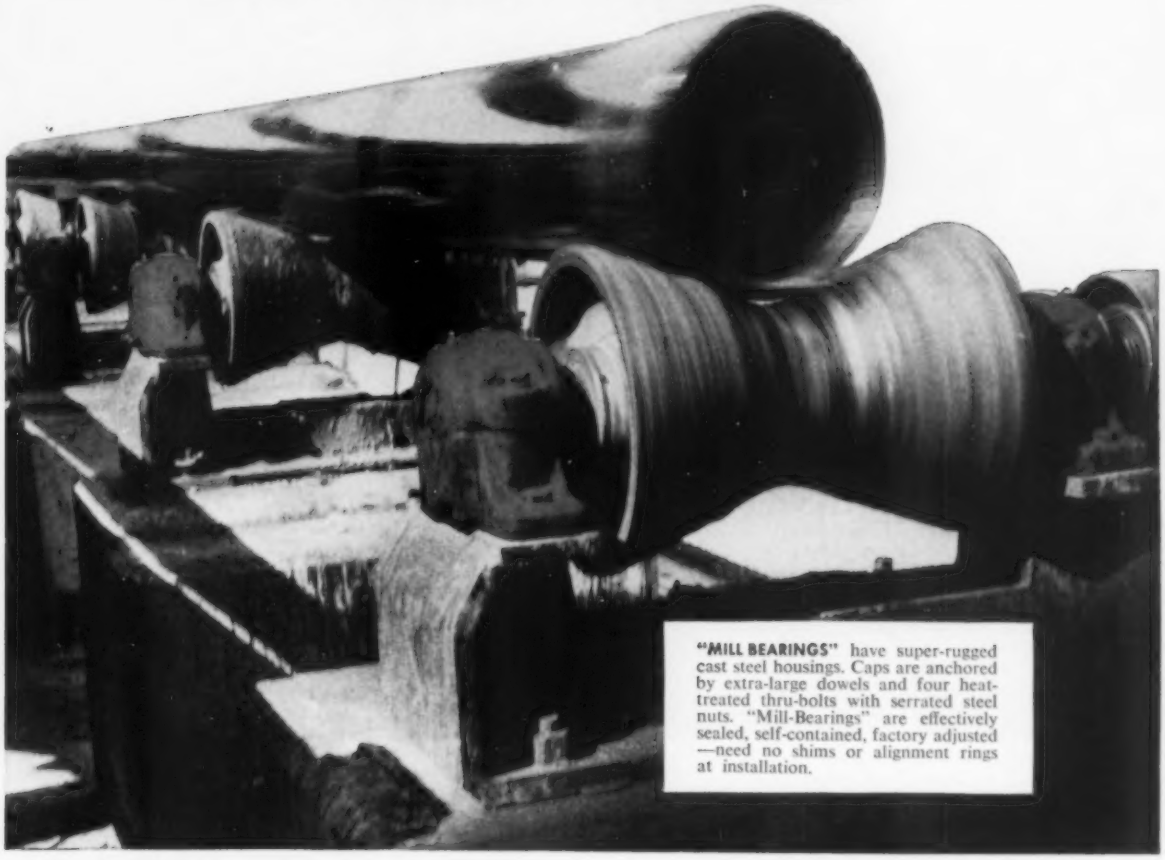
Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

HERE'S SELF-ALIGNMENT

in a steel housing



"MILL BEARINGS" have super-rugged cast steel housings. Caps are anchored by extra-large dowels and four heat-treated thru-bolts with serrated steel nuts. "Mill-Bearings" are effectively sealed, self-contained, factory adjusted —need no shims or alignment rings at installation.

LINK-BELT "Mill Bearings" compensate for shaft deflections in extra-severe applications

With cast steel housings plus *self-alignment*, Link-Belt "Mill Bearings" are a perfect match for the grind and grime of heavy loads in steel mills, mines, foundries and similar grueling service. They instantly adjust to shaft misalignment . . . accommodate minor inaccuracies of welded and concrete support structures . . . end need for extra-heavy shafting to avoid deflections which ruin ordinary bearings.

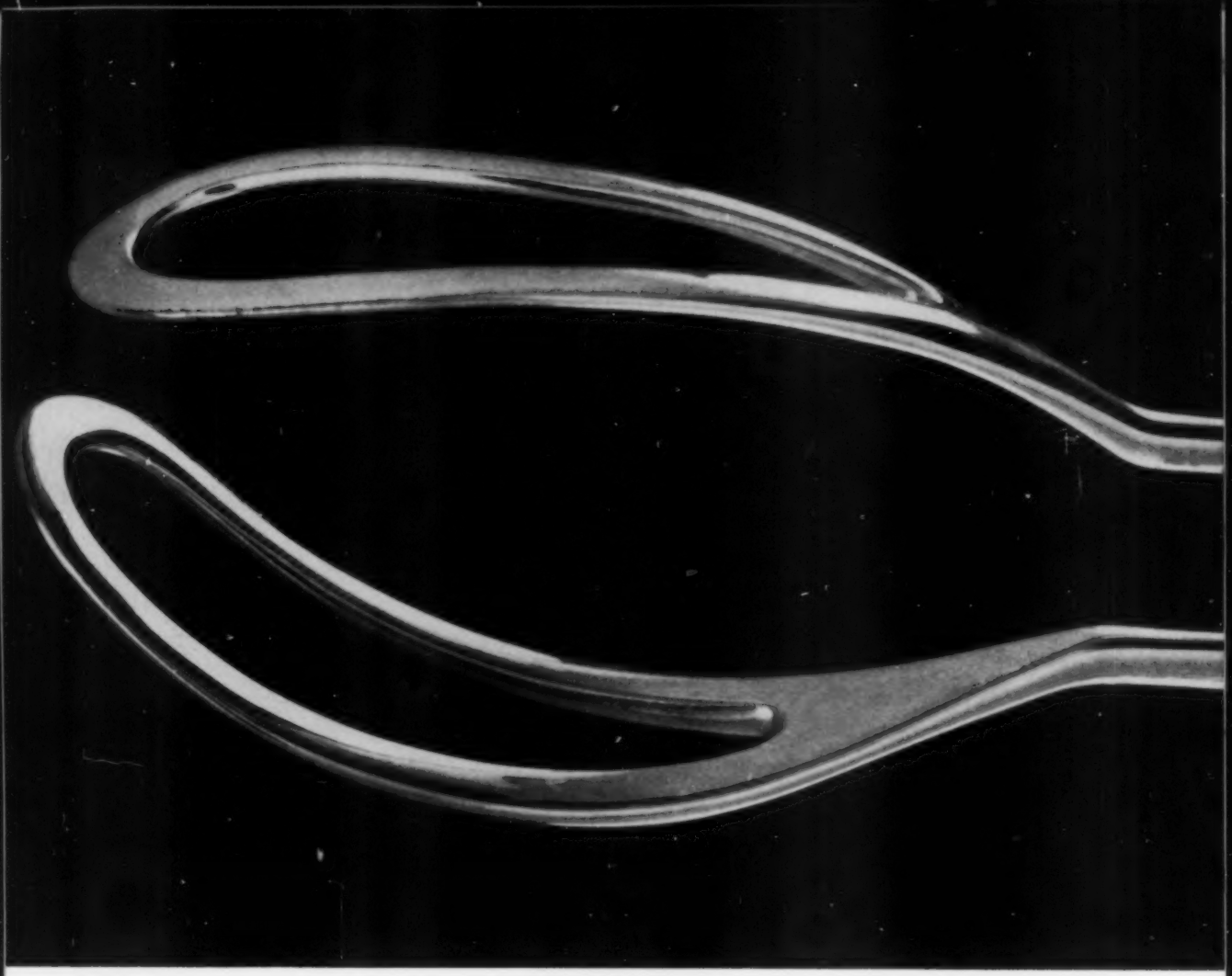
Link-Belt "Mill Bearings" are part of industry's most complete line of self-aligning ball and roller bearing blocks. You can get full information from any of 40 Link-Belt offices.

Spherical bearing is free to align in any direction, assuring full load capacity regardless of shaft deflection.

LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,108-A



Corrosion Resistance It is an immutable law of Nature that all things seek their most stable state. Nitroglycerine craves opportunity to explode back into passive water and gas vapor. Radium glows silently as it decays into lead. Metals yearn to return to their oxides.

Corrosion is simply the return of a metal to its most stable form. It's an electrochemical process that is generally speeded up by the presence of salts, acids and moisture—in fact, at humidities below 50% there is virtually no atmospheric corrosion of steel. There are six common ways to minimize corrosion: select the right steel, apply protective coatings, install cathodic protection devices, set up periodic cleaning procedures, control the corrosive environment, and use *design* techniques which reduce the likelihood of corrosion.

We have a record of one case where a manufacturer installed expensive piping to transport gaseous chemicals—overlooking the fact that ordinary carbon steel pipe would do the job just as well *if it were insulated* to prevent condensation of the chemicals inside the pipe. Sometimes a vessel is designed with great care so that it will hold a corrosive liquid, only to have the vessel attacked from the *outside* because the support brackets harbored pockets of moisture. And there are cases on record of stress corrosion failure because it was not recognized that stress relieving was necessary after cold working the metal.

Actual service records or true-to-life corrosion tests are the safest ways to judge a grade of steel, and you can often avoid the expense and time-consuming nature of making your own tests if you check first with United States Steel.

A corrosion problem that is new to you may be familiar to us, and we may be able to supply you with information that will solve your particular problem promptly.

Another good reason for coming to United States Steel is this: no matter what kind of steel you need, you're sure to find it among the vast range of USS Steels for Design. The final selection, of course, should be made by a skilled metallurgist. Our technical staff is always available to consult with you about your problems. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS **United States Steel**

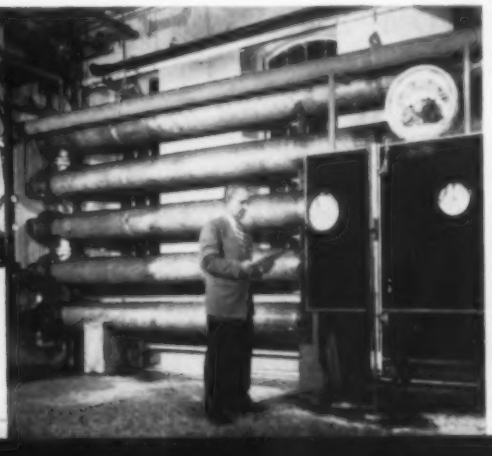
STEELS FOR DESIGN

Stainless Steel obstetrical forceps

Lower Left—Problem: The City of Pittsburgh wanted a trouble-free hull on their new, all-steel fireboat. Solution: Paasch Marine Service built the hull with ¼" USS COR-TEN High-Strength Low-Alloy Steel. Payoff: A light, strong hull that has four to six times the atmospheric corrosion resistance of carbon steel plus superior paint adherence.

Lower Middle—Problem: Combat corrosion in the new Carquinez Strait Bridge by designing smooth, welded members eliminating details vulnerable to corrosion. Solution: USS "T-1" Constructional Alloy Steel and USS TRI-TEN High-Strength Low-Alloy Steel, both weldable and both having superior resistance to atmospheric corrosion. Payoff: The smooth, welded framework will assure much lower maintenance costs than the annual $70,000 needed to paint and maintain the old, riveted bridge. (And a bonus advantage: "T-1" Steel's high yield strength permitted strong, lightweight design, saving $800,000 in over-all cost.)

Lower Right—Problem: Design a preheating unit for a textile plant to handle hot water with a highly corrosive caustic soda content. Solution: 19,000 lineal feet of Type 304 Stainless Steel tubing inside the Stainless shells. Payoff: Ludell Manufacturing Company predicts that the unit will last indefinitely.



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FIVE MOLY CARBURIZING STEELS ACCEPTED AS STANDARD AISI-SAE GRADES

AISI Number	C	Mn	P Max.	S Max.	Si	Ni	Cr	Mo	Corresponding SAE Number
4422	0.20/0.25	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.35/0.45	4422
4427	0.24/0.29	0.70/0.90	0.040	0.040	0.20/0.35	—	—	0.35/0.45	4427
4520	0.18/0.23	0.45/0.65	0.040	0.040	0.20/0.35	—	—	0.45/0.60	4520
4718	0.16/0.21	0.70/0.90	0.040	0.040	0.20/0.35	0.90/1.20	0.35/0.55	0.30/0.40	4718
8822	0.20/0.25	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.30/0.40	8822

Wide use in automotive transmission and differential ring gears and pinions results in recognition of Molybdenum's economical contribution to case and core hardening in carburizing steels. These economies can be useful in most of your carburizing applications. Now available through your steel suppliers.

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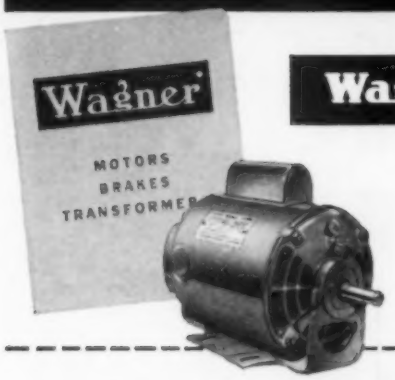
Which of these ELECTRIC MOTOR BULLETINS can be helpful to you?

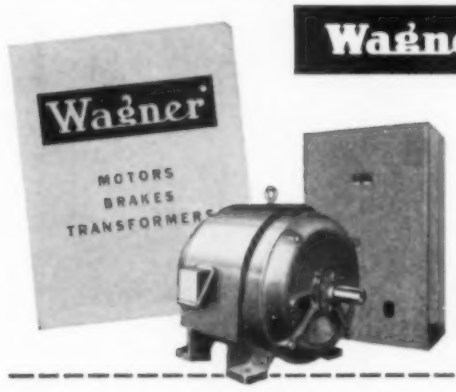


Wagner **FRACTIONAL HP MOTORS**

Bulletin MU-211. Illustrates and describes both single-phase and polyphase squirrel-cage motors, open and enclosed types; also fan and blower motors and jet pump motors.

Wagner **INTEGRAL HP MOTORS**

Bulletins MU-212, 213. Cover single-phase ratings through 15 hp, and polyphase squirrel-cage motors through 1000 hp, open and enclosed types; also multispeed, punch press, crane and hoist, and wound rotor polyphase motors.



Wagner **MOTOR-STARTER COMBINATIONS FOR REDUCED CURRENT STARTING**

Bulletins MU-124, 128, 195. Illustrate and describe the Wagner part-winding motor and starter combinations that limit inrush of starting current in squirrel-cage motors up through 500 hp—meet all starting requirements of AEIC-EEI-NEMA.

In addition to a complete line of standard motors, Wagner also furnishes tube ventilated motors through 500 hp, vertical and flange mounted motors, hermetic motors, gear motors, and direct-current motors. Consult the nearest of our 32 branch offices, or write for specific information on these special application motors.

WM88-18

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Please send me the following Electric Motor Bulletins:

- ☐ MU-211 Fractional hp Motors.
- ☐ MU-212, 213 Integral hp Motors.
- ☐ MU-124, 128, 195 Reduced Starting Current Combinations.
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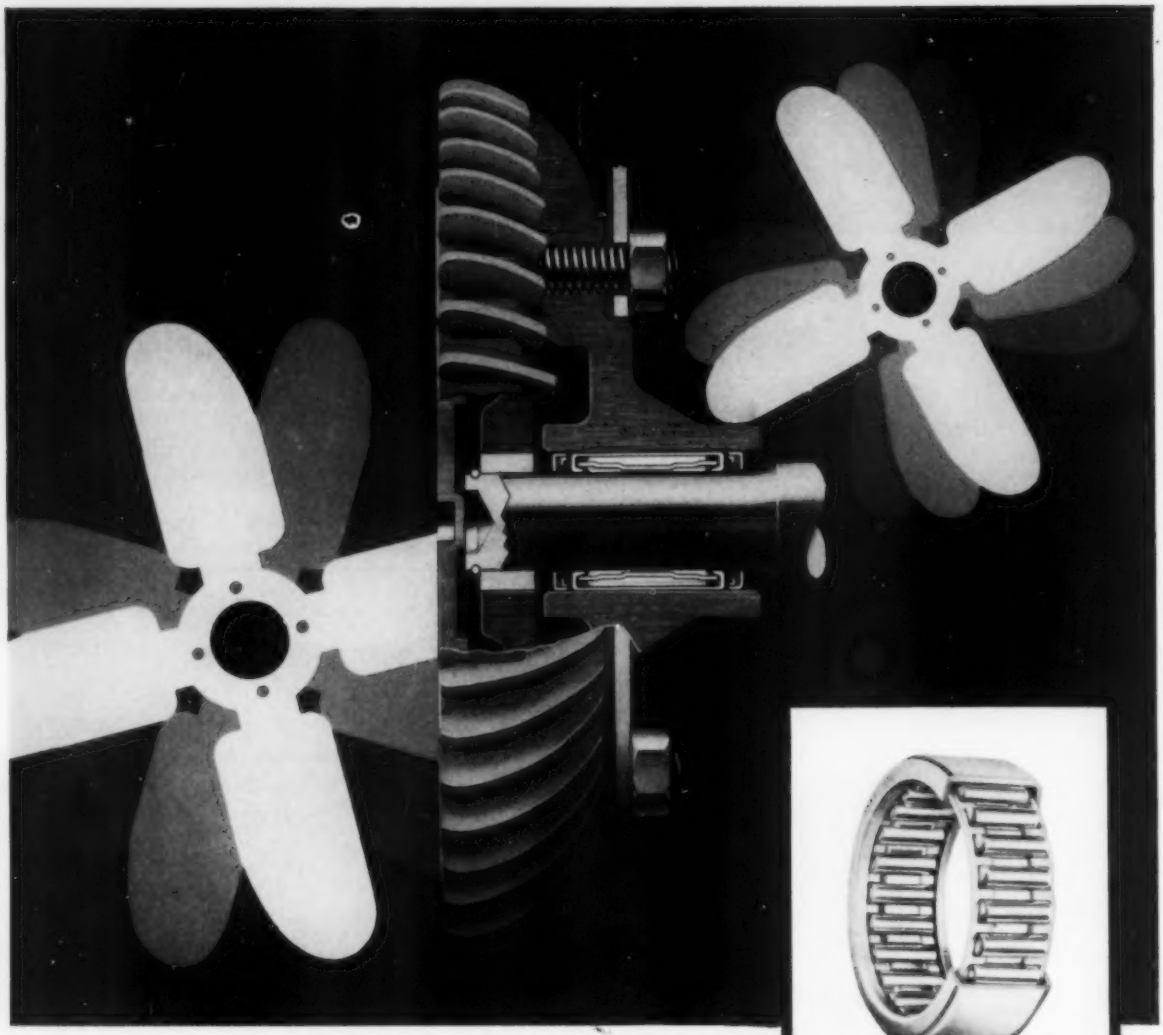
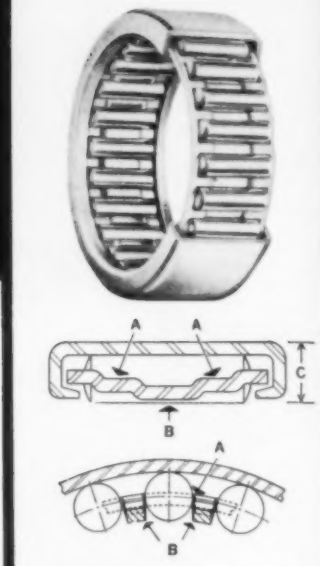


Schwitzer Variable Speed Fan Drive features new Torrington Bearing for economy, stability, lifetime lubrication

The original design of the Schwitzer Fan Drive, used in passenger automobiles to reduce fan horsepower and noise, called for two ball bearings. By replacing these with one Torrington Drawn Cup Roller Bearing, Schwitzer engineers have simplified the design and reduced costs.

This unique bearing firmly supports the drive housing and fan so they run true despite possible couple loads due to gyroscopic action. Ample lubricant reserve capacity permits pre-lubrication for the life of the fan drive.

Many new opportunities for economy, design simplification and operating improvements are opened up to engineers and designers by the new Torrington Drawn Cup Roller Bearing. Services of Torrington's engineering staff are offered to help you with product development work. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**



- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
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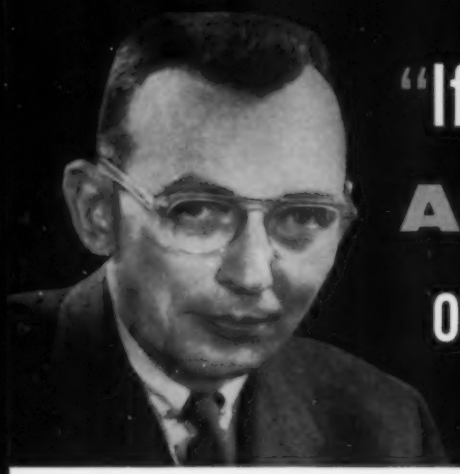


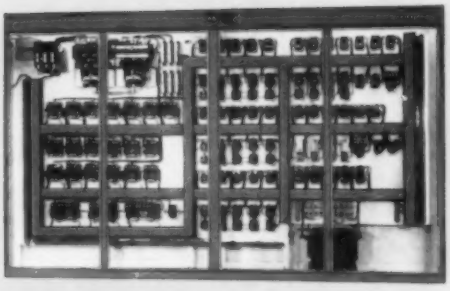
"If we stick to ALLEN-BRADLEY... our control troubles evaporate"

...so says John A. Bradner,
President, Lees-Bradner Co.,
Cleveland, Ohio, machine tool manufacturer.

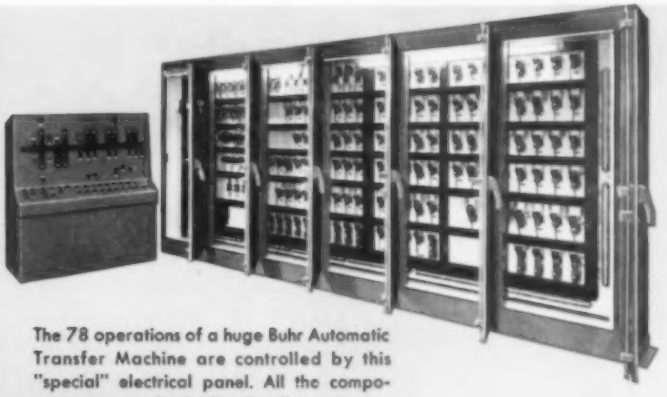
"Yes, we have chosen Allen-Bradley controls. We use them, like them, and most thoroughly approve of them. We do our level best to see that they're the ones with which LEES-BRADNER machines are equipped.

"It has been our experience in over 25 years of pioneering electrical rather than mechanical control of machine tools that, if we stick to Allen-Bradley, control troubles we are too apt to have otherwise—*evaporate!*"

Lees-Bradner Gear Hobbing Machine, above, uses six motor control panels assembled from standard A-B components.



This is the electrical control panel for a 12-station Kingsbury Indexing Automatic which performs 19 operations on an automatic transmission part. All the components in this panel are standard A-B control items.



The 78 operations of a huge Buhr Automatic Transfer Machine are controlled by this "special" electrical panel. All the components are standard Allen-Bradley units.

A-B QUALITY

ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

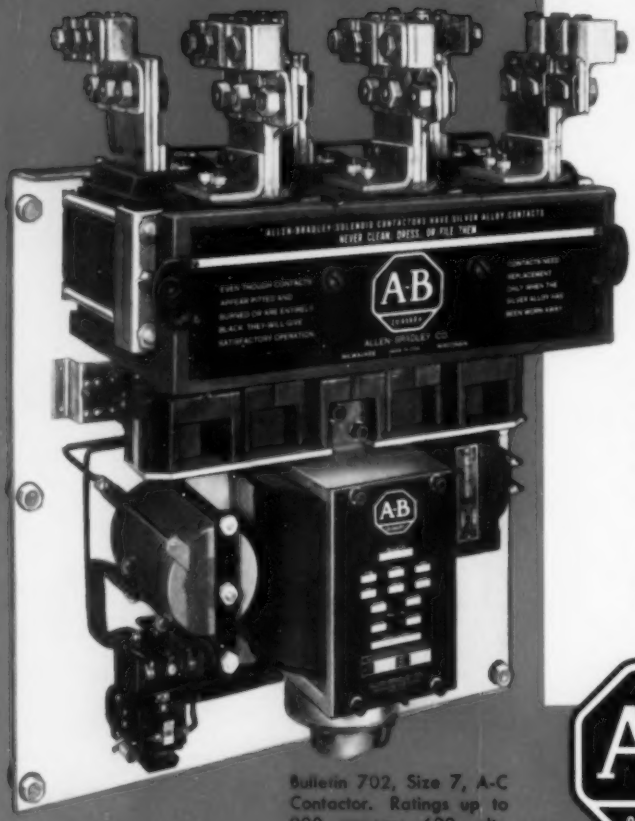
10-58-R

only

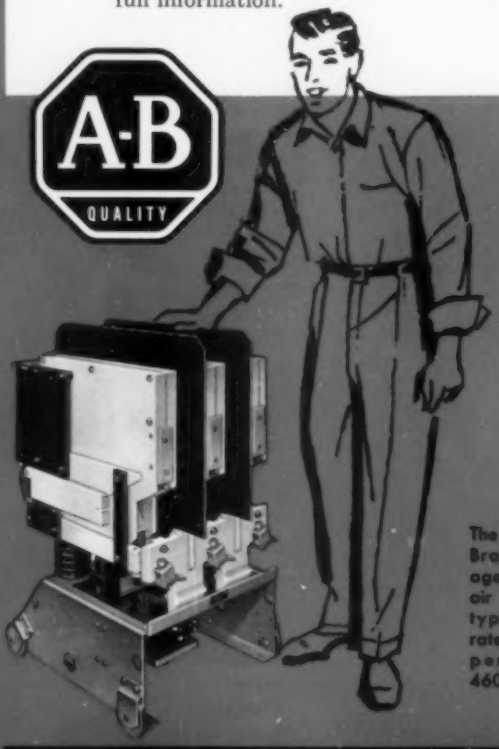
ALLEN-BRADLEY gives you Trouble Free Solenoid Starters in ALL SIZES!

The simple solenoid design—exclusive with Allen-Bradley in the big starter sizes—has only one moving part. This eliminates the trouble causing bearings and flexible jumpers of conventional clapper switches . . . and assures millions of trouble free operations. A-B solenoid starters also have double break, silver alloy contacts that never need any servicing. They are always in perfect operating condition—until the contact is completely used up.

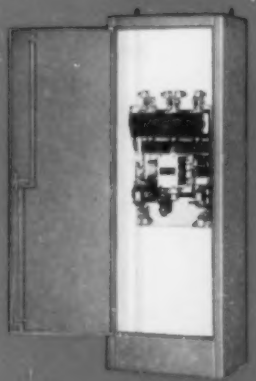
This time-tested solenoid construction is available on *all* Allen-Bradley starters up through Size 7 . . . as well as on A-B's rugged, air break, high voltage starters. Write for full information.



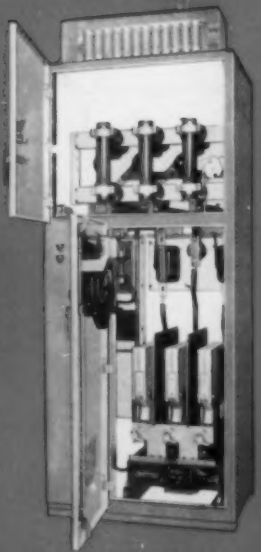
Bulletin 702, Size 7, A-C Contactor. Ratings up to 900 amperes, 600 volts. This basic solenoid contactor is used in large A-B low voltage starters.



The heart of Allen-Bradley high voltage starters is this air break, solenoid type contactor—rated at 400 amperes, 2300 or 4600 volts.



Bulletin 709 across-the-line solenoid starters are made in ratings to 300 hp, 220 v; 600 hp, 440-550 v.



A-B high voltage starters are built for all types of motors. Ratings to 1500 hp, 2300 v; 2500 hp, 4600 v.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

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10-58-MR

DEVELOPMENTS TO WATCH...

More carbide coatings . . .

. . . for graphite and other materials that must be protected against oxidation and chemical corrosion are promised by research now underway at Battelle Memorial Institute. One such coating, using silicon carbide, is already on the market (*PE—Sept 15, p 35*), but there are other possibilities, among them, carbides of columbium, tantalum, and zirconium.

Major problem in development of these coatings, Battelle says, has been finding a way to control uniformity. Standard vapor-deposition techniques were not satisfactory, especially on small-bore, tube-like hollow parts.

Now, says Battelle, a new vapor-deposition process "makes the rate of coating formation practically independent of the vapor-flow pattern, and a uniform coating results."

Key to the new process is control of temperature and pressure during deposition. The range of temperature for producing a successful carbide coating is higher than that usually used for metal, while the range of pressure is lower.

Coatings ranging in thickness from 0.05 to 0.5 mm have been produced and, says Battelle, the process looks commercially feasible not only for coating graphite parts, but also for creating new compounds and alloys by reaction of the base materials with, for example, a dissociable metal halide vapor at appropriate pressures and temperatures.

More power from conventional fuels . . .

. . . is promised by research now underway on the effects of nuclear irradiation.

At the recent ACS National Meeting Farrington Daniels pointed out that proton and neutron bombardment can alter the basic structure of fuels in such a way that their energy content is increased by a substantial amount. This effect was first demonstrated by combustion tests on graphite taken from nuclear reactors, and is now the subject of active research programs in government and industrial laboratories.

Studies at the Bureau of Mines have shown that irradiation of low-grade lignite coals can upgrade them to the point where they are comparable in energy output to bituminous coal. On the other hand, irradiation of higher grade coals may have an equally useful degrading effect.

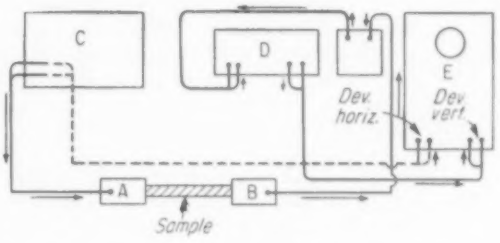
Denver & Rio Grande Western Railroad, for instance, has been working on methods for using coal —in finely divided form—as a diesel fuel. Here, the need is for finer particles—comparable with conventional petroleum fuels. Research is still in progress, but Rio Grande research director Ray McBrian says irradiation tests thus far indicate irradiation can accomplish this useful type of degradation and produce coal and coal-oil mixtures suitable as diesel fuels. Furthermore, he says, while much work remains to be done, this approach "offers great promise for the use of such solid fuels as coal . . . in almost any type of internal-combustion engine."

Internal vibration is the key . . .

. . . to a nondestructive system devised in France for testing thermal shock resistance of ceramic and clay products. Noting that such resistance is inversely proportional to elastic modulus and damping properties, the French researchers measure the latter two qualities with this simple electronic system:

The sample is positioned as indicated between an exciting electrode A and a receiving electrode *B*. The output of a low-frequency generator *C*, adjusted for resonance, is fed to the sample through A. The second electrode then converts this vibration to an electrical signal and sends it to a voltmeter *D*—and a cathode-ray oscillograph *E* where horizontal and vertical deviations are displayed and can be measured.

Tests show, say the French, that in clay products impregnated with water and subjected to repeated freezing and thawing, the modulus remains practically unchanged until internal cracking begins; then decreases considerably even before the cracking becomes apparent. The elastic modulus can also be used for control of curing temperatures since it increases sharply as the temperature rises.



DEVELOPMENTS

TO WATCH...

Constant-speed hydraulic drives . . .

. . . for service at temperatures to 700 F are being developed at Vickers engineering laboratories. First step was substitution of ferrous for nonferrous metals in working parts, elimination of nonmetal bearing retainers, development of special high-temperature steels and temperature-stabilized bearings. Now, Vickers engineers are evaluating such design changes as these:

- "Tin-can" housing constructions, using steel-frame and sheet-steel weldments to reduce thermal distortion.
- Closed, airless pump-motor circuits to minimize fluid oxidation and provide systems that are insensitive to altitude and relatively unaffected by the forces of acceleration.
- Self-contained, sealed gear cases in which inert gases can be used as lubricants, to eliminate or minimize external circuitry.

Anti-yellowing agents . . .

. . . for thermosetting as well as thermoplastic materials have been developed by American Stearin Co, New York City, and are now in pilot production. The company claims these are not dyes that cover up color, but are compounds that inhibit color-development.

They're expensive (tentative price is $9 a lb), but are used in such small quantities (0.01 to 0.05%) that, says American Stearin, they should add no more than ½¢ a lb to cost of the finished product.

For best results on thermoplastics the anti-yellowing agents must be added before polymerization; for thermosetting materials, on the other hand, the best time is before curing.

Sparking lead-zirconium alloys . . .

. . . that act much like flints for lighters have been developed by Metal Hydrides Inc. It says these alloys, roughly 50% lead and 50% zirconium, can be custom-tailored to deliver a specified pyrophoricity. Surprisingly close control of both spark size and spark temperature is possible.

Less is known about why these alloys behave the way they do. Latest explanation is that the metal actually contains tiny particles of pure zirconium which break off and ignite as the metal is struck.

No commercial applications for the materials have developed so far, but they might prove useful in mechanical igniters and also find a number of specialized military uses.

Transparent film with corrosion-inhibiting . . .

. . . coating has been developed by Daubert Chemical Co, Chicago, and is now ready for marketing. This is a Mylar polyester film with a volatile corrosion inhibitor on its surface. Primary aim was packaging machine parts and other products, because visibility here is combined with protection; but the strength, electrical properties, and sealability of the film itself, combined with the corrosion protection it offers, might well recommend it for consideration as an insulating tape or instrument window.

Air turbines and generators . . .

. . . that can be direct-coupled and will deliver 40 kva or more of 400-cycle current, have been built by GE, and are now undergoing test.

As GE engineers pointed out to the SAE National Aeronautic Meeting, design of an integrated air turbine-ac generator unit that can be attached to the same shaft without step-down gearing was made possible by new 24,000-rpm, 400-cps generators.

In the combination unit (GE calls it a *Turbonator*) now undergoing test, titanium is used for top-sticks and retaining rings, and several other innovations are being considered. Say GE engineers S. F. Richardson and J. W. Haynes, "Ceramic wire insulations capable of withstanding winding temperatures over 800 F appear to be available, techniques for winding ceramic-insulated wire are being developed . . . and high-temperature rectifiers such as silicon carbide and gallium arsenide show promise." Sealed oil and gas bearings have both been tried, with the latter apparently the best choice. —ARC

Sharpest New Product Eye: Management or Research?

NEW YORK—When research and management team up, which is the cart and which the horse? Should the technical departments lead the company into new-product areas? Or should management blaze trail.

The argument was aired at a recent Special Research and Development Conference of the American Management Association here. Opposing views came from Dr. E. R. Piore, IBM's director of research, and F. B. Newcomb, American Can Company's vice-pres. for commercial development.

Dr. Piore listed two conditions essential for a successful R & D program: The company must have a clear idea of why it is in research, and the research department must have a competent staff. He looks to company management to decide how much effort should go into pioneering new markets with revolutionary products or services, and how much into new products and product improvement. If competent research men are given these objectives, says Dr. Piore, they will then inevitably choose projects that serve the company well—the man in the lab knows best what investigations will be significant.

Mr. Newcomb led off by declaring that quality of a company nowadays, particularly in financial circles, is judged by the size of its R & D program. But, he argued research is a good gage only if the department is well managed. Company management must therefore set up financial goals, then outline specific steps for the research and engineering groups. In Mr. Newcomb's view, top management gets its guidance from market-research surveys, long-term economic analysis and other studies.

Their differences, the contenders agreed, arose over a distinction between research and product-improvement or adaptation. Where the problem hinges on money and effort alone, and where the solution can be found in existing information, Dr. Piore conceeded, market research and economic surveys can guide engineering departments. But where the problem is less clear-cut, the man personally at grips with the physical world can throw great illumination on nature's hidden potentials and how to use them. All the market analysis in the world, he said, could not have suggested invention of the telephone.

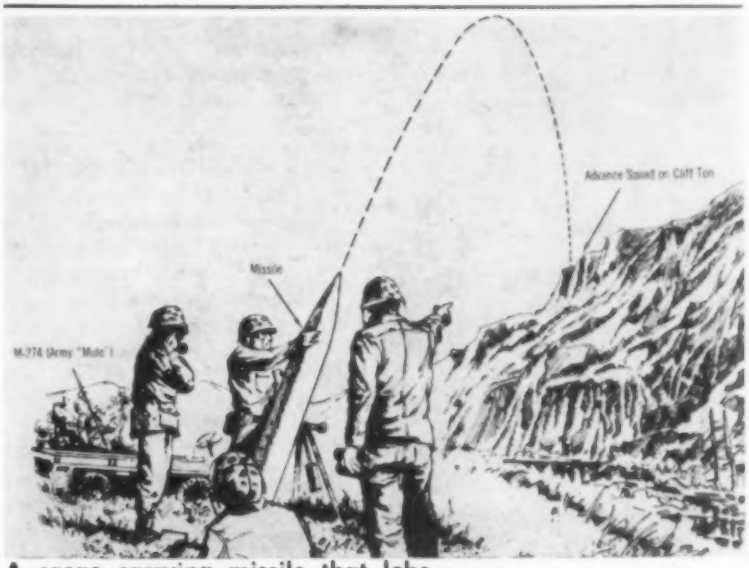
Third speaker on the program, Dr. J. A. Hutcheson, vice-president of engineering and research at Westinghouse, said the job of the engineering department is to apply knowledge from the research lab to build apparatus for profit. This implies two levels of problems in his company, he said. Short term, it means improving existing products through cutting costs, improving quality and performance. Long term, it means keeping in close touch with trends in technology and with the state of the art in order to make fundamental improvements in apparatus. And it means making certain that the research dept. will have technology and materials available when engineering dept. needs them.

Khrushchev Shakes up USSR Education System

Moscow—A drastic change in Russia's educational system will be made during the next four years, according to Premier Khrushchev. He accompanies his announcement with stinging, revealing criticism of the present system.

Henceforth, Soviet youth will spend eight years in school followed by two to three years in the factory, or on the farm. Only after this "on-the-job" training will students be permitted to resume studies at universities or technical institutes.

Previously, Soviet youth attended secondary schools for 10 years, followed by training at higher schools of learning. However, Kremlin leaders have noted a reluctance on the part of many graduates to apply their learning in the factories or on the farm. In addition, there has been criticism of high schools (*PE—Sep 1, '58 p 21*) prepairing students for careers in obsolete fields while specialists in electronics and automation are needed.



A cargo carrying missile that lobs . . .

rations, ammunition, medicine, communications equipment and other supplies to troops stationed over a hill has been developed for the Army by Convair Div, General Dynamics. It will deliver supplies where terrain is impenetrable and weather or enemy action prevent air drops. It is also adaptable to offensive weaponry carrying payloads of napalm, chemicals, high explosives or small nuclear warheads. Called the Lobber, the missile can be carried by three men in the field giving mobility needed by Army's new pentomic units. Payload sections of the Lobber can be pre-filled at supply depots. An estimated 70% of the missile is reusable. General Dynamics has not released details of the missile's dimensions, payload, launching or landing techniques.

Cancellation of Canada's Arrow Seen as Jolt to Future R&D

TORONTO—Cancellation of the contract for Avro Aircraft Ltd's Arrow, (below) a 30-ton, Mach 3 interceptor has been viewed here as an end to Canadian efforts to ever design and build its own military planes. Pessimistic views have ranged from a possibility of inhibiting original R&D in many related fields, to a complete loss of confidence in government–sponsored R&D programs.

After more than six years and $400 million worth of intensive development, the program was cancelled by the new Conservative government committed to tax reduction. By the time the Arrow would go into squadron service in 1960, it is estimated that it would have cost around $2 billion. As reported by Franklin Russell, PRODUCT ENGINEERING's Toronto correspondent, "The Arrow program was a special deal.

"It was special because it was designed specifically to be the first intensive effort to put Canada on the map as a research, design and development power. It was designed to help develop an electronics industry second to none. It was expected that the Arrow's electronic suppliers would branch into other projects. The program was aimed at halting the flow of skilled manpower to the US, both from universities and industry. It was to create an all-Canadian plane for peculiar Canadian conditions—vast distances, few airfields and intense cold."

As many sub-contractors gambled their futures on production contracts, it has been estimated that cancellation of the program will probably destroy about 50 of these firms and seriously hurt a hundred others. Reportedly, it was understood by Avro and the 650 suppliers that with R&D underwritten by the government, some production contract was inevitable. The initial government order is for 37 planes.

Prime Minister Diefenbaker said that the Arrow program would be reviewed next March. Avro indicates that this means cancellation, for the company must have a full production contract by December to stay full-time on the project.

Urge Standardization of Support Equipment

LOS ANGELES—About 78% of the ground support equipment (GSE) for a modern bomber squadron is nonstandard. When a new bomber goes into production, most of the equipment is obsolete, and that's why Air Force budgets skyrocket.

This point was made by Maj Gen A. G. Hewitt, director of Maintenance Engineering, Air Force Engineering Hq. Washington, D. C., when he spoke before the Society of Automotive Engineers' committee on aircraft and missiles support equipment.

Since, approximately 12,000 new supply items enter Air Force inventory each month, he urged that standardization should be applied during the design stage; especially because standard support and test equipment could still be developed for the B-70, F-108 and missiles now in R&D.

To overcome the lack of information available to contractors for maximum integration; a technical data file, being developed jointly by the Air Materiel Command and industry, will be available by Jan 1959.

Spurred by the realization that GSE items have become more expensive than the vehicles they support, the Air Force is seeking to achieve standardization by examining the following areas:

- The make/buy structure of contractors. This will be done to make use of as much existing GSE as possible, to increase standardization, and to reduce overall equipment costs.
- Multiple use equipment.
- A centralized procurment of appropriate prime equipment.
- Assigning to one depot the responsibility for technical coordination of all major test equipment items.
- Assigning of a single maintenance engineering representative to each weapons system phasing group whose prime responsibility will be to promote standard support equipment and ease of maintenance.

Removable Connectors Shown to be Reliable

DOWNEY, CALIF.—Reliable Electrical Connections Conference, to be held in Dallas, Dec. 2-4, has already released reprints of its important papers, and is publishing all of them in book form next month.

Typical is "Connect-disconnect Plugs," by I. G. Rabbin from Autonetics Division of North American Aviation, Inc. It shows statistically that 'unreliability' is less the fault of removable connectors than the fault of components such as potentiometers and resistors. This table makes a direct comparison:

Element	Typical No. Per System	Failures in 1,000,000 hr	% Total Failures
Connectors, (removable)	101	80.8	2.2
Soldered connections	1000	400	10.84
Tubes, transistors	100	100	2.71
Diodes	110	495	13.4
Gyros	1	50	1.35
Inductors	2	4	.1
Motors	3	150	4.06
Potentiometers	26	1040	28.25
Relays	15	375	10.23
Resistors (fixed)	440	616	16.76
Switches	11	110	2.9
Transformers	9	90	2.44
Choppers	1	5	.13
Printed ckt. board	20	20	.54
Capacitors	180	151.2	4.09
	Total	3687.0	100.00

Printed Circuits Have a Future; Their Designers, Many Headaches

CHICAGO—Printed-wiring fabricators have their work cut out for them in the next five years. Those with an ear cocked to the first gathering of the Institute of Printed Circuits heard that circuit users want standardization, reliability, improved line detail, dimensionally stable base material, miniaturization. And they want it all at lower cost.

A variety of views from specialists in the fields of radio, TV, appliances, industrial electronics, and guided missile specialists were aired and debated at all-day sessions. Here is a compendium of the views:

Printed-wiring fabricators have a bright future, said J. B. Schickel, component engineer of General Electric Co. Conservative estimates point to sales of 30,000,000 TV sets in the next five years, and the printed-wiring industry will probably produce a large part of the circuits.

But Schickel added, the TV-electronics industry wants units to withstand high temperatures in TV sets that result not only from the sets' greater power, but the fact that there is less area to dissipate it. Shoot for a board that lasts 7 years at 125 C, and still costs less, he said. He also called for stronger base materials that are truly cold-punchable, boards that are consistently flat, and protective coatings that are eternally solderable. Viewing radio needs, F. W. Whitford, Delco Radio Div of General Motors, said Delco production lines will consume 300,000 sq ft of circuit boards in 1959 for 2 million car radios. Design trends at Delco point to smaller radios that fit instrument panels crowded with new accessories. Ultimately, space restrictions may mean assembling several small boards at right angles or in parallel, using modules with multi-plane circuitry and component assembly, or possibly, double-sided boards. The latter will be satisfactory only if cost is cut and reliable through-connections become available.

"Standardization" was the battle cry of Temple Nieter, chief, Special Projects Engineering, Warwick Mfg Corp. He urged companies to circulate standardization methods and ideas for printed wiring that they find successful. Such ideas will permit quick overnight design changes. He called also for soldering standards to "get out of the morass of variable approvals." Nieter predicted new applications for printed wiring—many of them in the consumer field: home lighting controls, toys, stereophonic sound and electrical musical instruments.

The acclaimed Tinkertoy concept now needs complete reappraisal, in the view of Dr. T. D. Schlabach, member of the technical staff for printed wiring materials and processes, Bell Telephone Labs. The ultimate—though remote—goal he suggested, is a circuit generated from a single crystal. More immediate goals for printed circuits in industrial applications, he said, are increased dimensional stability, consistent electrical properties, resistance to humidity, and a means of controlling contamination—now the greatest barrier to reliability. He forecast ceramic material for circuit boards, and noted that important work is already being done in punching and firing ceramics and on fired conductors other than silver.

Components and devices will be miniaturized to fit lines and spacing as narrow as 0.002 and 0.001 in., said E. J. Lorenz, manager of IBM's printed circuit laboratory. At present, line widths of printed circuits in production are ½ in., and spacings of 0.002-0.003 in. have been made, cost too much to become production items. He noted that the English are doing finer line-detail work than he has seen in this country. Plated-through holes, he believes, will be more economical than eyelets where many holes are needed per panel. In addition, plated-through holes are easier to handle with miniaturized circuits.

Digital computers for airborne guidance will be small enough to be held in the hand in five years, J. J. Staller, Senior Engineer, Missile Guidance, American Bosch Arma, predicted. "We have passed through miniaturization, subminiaturization, and are now talking micro-miniaturization, microcircuitry or molecular circuits," he said.

R. A. Gerhold, chief of the R & D lab, modular circuit systems section, Fort Monmouth, prophesied that printed wiring will be used in 80 to 90% of military applications. Conventional components allow 50,000 parts per cu ft. Target with micromodules, he said is 600,000 parts per cu ft, with two-dimension circuitry reduced to wafe size.

Small Computer Leads Copter To, From Target

GREAT NECK, NY—A pushbutton navigation system that accurately guides helicopter pilots to and from a series of targets—even when home base is a fast-moving ship—has been devoped by Sperry Gyroscope for the Navy. A lightweight airborne computer and a single pictorial cockpit indicator comprises a self-correcting system that selects the most reliable data—whether radar or radio signals, or latest correct air-mass information.

Before flight, pilot sets target, base and wind information in computer. At takeoff, the computer is started and

drives a compass pictorial displacement indicator. A V-bar on the indicator points out target direction and a counter, Like an automobile mileage indicator, shows the distance to target.

Pilot can change destination at will, or cancel preflight plans and return.

The 25-lb computer uses Doppler radar data, and occasionally TACAN radio signals, to provide precise guidance. When Doppler signals become unreliable, computer automatically disregards them, functions on air-mass

data alone. It uses last accurate wind data retained by memory system. Automatic computer circuits make corrections in air-mass data from radio signals, even when sporadic, then fly a course based on corrected data until further radio guidance is received.

The system will be used on anti-sub screening and killer missions.

3-D Radar Has no Moving Scanner

WASHINGTON—Radar has gone three-dimensional with a new system developed by Hughes Aircraft Co. that simultaneously computes distance, bearing and altitude. While claiming that the new radar had "extreme range," the Army refused to quote figures. The system is called Frescanar (frequency scan radar), and is used with the Missile Monitor, a mobile air defense missile system.

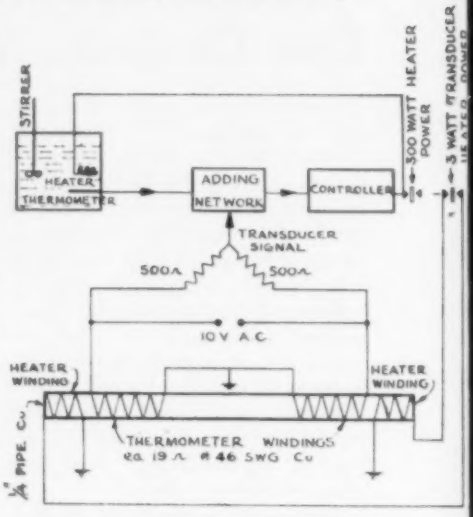
Big difference between this system and conventional radar systems is that Frescanar required no physically moving antenna for scanning. The scanning radar beam is radiated from the antenna at different angles depending upon the frequency of the energy applied to the antenna. This also permits scanning at greater speeds than is possible with a physically moving antenna.

Thermal Transducer Reduces Temp. Fluctuation

MELBOURNE, AUSTRALIA—A thermal transducer developed by the Commonwealth Scientific & Industrial Research Organization here is being used as an on-off temperature controller for systems subject to "over-shoot." Similarly it can be used as an on-off control of cooling or refrigertion, proportional control of these quantities, with or without reset, or floating control. Or, to any controller where integrating feed-back will improve its performance. CSIRO says that it has advantages over equivalent electrical networks where long time constants are involved.

The transducer (right) consists of a metal rod or pipe with an electric resistance heater on both ends. Symetrically spaced about the center of the rod are two identical temperature sensing windings. The heaters and the windings are electrically insulated from the rod but thermally connected to it. The two windings are connected in two adjacent arms of a Wheatstone bridge circuit.

The controller regulates the power supply to the heater according to signals from the temperature sensing element. The thermal transducer generates a signal corresponding to the temperature rise in the controlled medium after heater is disconnected.

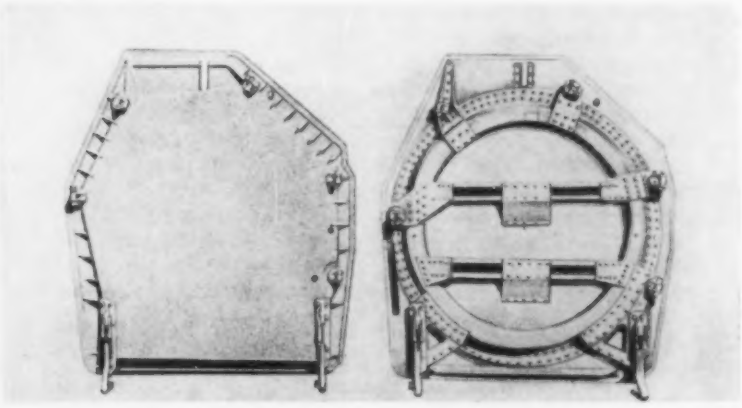


Before this stirred water bath had an integrating thermal transducer included in the circuit, temperature fluctuations were ±0.12C. With the thermal transducer, the fluctuation was reduced to ±0.01C. The limitation in this case was the dead zone of the controller itself.

An important characteristic of the thermal transducer, according to CSIRO is that long time constants are possible without use of the components required in a electrical circuit.

Casting saves $530 . . .

Northrop Aircraft Inc has successfully completed trial production of a one-piece cast-magnesium landing gear door for the F-89. This casting, essentially two thin skins connected by suitable ribs and braces, requires machining only the hinge and latch mounting pads. It replaces a fabricated door consisting of 55 aluminum stampings and 1640 rivets. According to Northrop, static tests show the doors greatly exceed test requirements. An accelerated cycle test caused only minor damage that left the door still in usable condition. Because of increased stiffness, Northrop expects the cast door to give better aerodynamic performance. Other castings were made, and one is to be flight-tested. Northrop expects to save $530 per door over the conventional design, at no increase in weight.



Machine-Tool Designers Announce New Control Developments

HARTFORD—What will the new look in machine tools be like? Members of the American Institute of Electrical Engineers got a preview here at their machine-tool conference. The papers read to them, as well as informal discussion that followed, brimmed with accounts of technical achievements that will influence design and capability of machine tools. Below are some of the more significant developments. Others will be discussed in greater detail in a forthcoming issue.

Numerical control is overseeing more machining jobs in a new tape-controlled machine described by W E Brainard, chief engineer, Servo Machine Tool Div. of Kearney and Trecker Corp. The machine, suitable for manufacturing heavy capital equipment, includes a hydraulically driven horizontal spindle, a magazine of 30 spare tools, and a worktable that rotates automatically to any one of eight positions. It is unique because it drills, mills, taps, and bores a workpiece an unlimited number of times in a single setup.

A tape masterminds all operations —even limited profiling. The tape orders an automatic loader to pick the right tool from the magazine, removes the one in the spindle and returns the old tool to the magazine. The human monitor need only make certain the magazine is loaded and the workpiece clamped.

The machine is a nut-and-bolt expression of Kearney and Trecker's control philosophy. Company policy makers are convinced numerical control is the key to production but that it should be applied primarily to manufacture of capital equipment—agricultural machinery, machine tools, coal diggers, printing presses etc. (For more on numerical control, see p. 50, this issue; and Oct. 20, p. 23).

Static devices are gaining importance. General Electric now has a prototype 50-amp controlled silicon rectifier that competes with a thyratron of equal size. On order from a a small pulse signal (less than 3 v, 50 ma) that is applied to its control element, the rectifier will switch a high current. It is more efficient, has lower trigger voltage and operates faster than a thyratron; but it will not tolerate overvoltage, overcurrent or high temperature as well as its counterpart. Because of the sensitivity a controlled silicon rectifier needs for triggering, it possesses somewhat lower operating limits than a plain silicon rectifier. This 50-amp version will be available from GE in January.

Magnetic amplifiers and switching reactors—which also are static devices —to control power outputs up to 200 hp will be offered soon by several companies, and there is no barrier to higher powers.

Coming Events

OCTOBER

26-29 . . . . American Gear Manufacturers Association, Semi-annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

26-31 . . . . American Institute of Electrical Engineers, Fall General Meeting, Penn-Sheraton Hotel, Pittsburgh, Penna.

27-29 . . . . National Lubricating Grease Institute, 26th Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

27-30 . . . . American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Fall Meeting, Carter Hotel, Cleveland.

27-29 . . . . American Gear Manufacturers Association, Semi-annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

27-31 . . . . National Metal Exposition, 40th National Metal Exposition & Congress, Cleveland Auditorium, Cleveland.

28 . . . . Ultrasonic Manufacturers Association, Annual Meeting, Hotel Cleveland, Cleveland, Ohio.

29-30 . . . . Armour Research Foundation, 5th Annual Computer Applications Symposium, Morrison Hotel, Chicago, Ill.

29-31 . . . . Metal Treating Institute, Annual Meeting, Hotel Cleveland, Cleveland, Ohio.

NOVEMBER

3-5 . . . . National Fluid Power Association, Fall Meeting, Drake Hotel, Chicago.

4-6 . . . . Institute of Radio Engineers, National Automatic Control Conference, Sheraton-Dallas Hotel, Dallas, Texas.

Who Will Control US Space Program?

WASHINGTON—The question of military vs civilian control over future US space exploration has once again boiled into bureaucratic controversy.

At issue is the plan of the National Aeronautics & Space Administration, (NASA), the new civilian agency, to take over management of the $57.5-million labs of the Army Ballistic Missile Agency (ABMA) at Huntsville, Ala, and Army's $23-million Jet Propulsion Labs (JPL) operated at Pasadena, Calif. by Cal Tech.

NASA has already assumed technical administration of the nonmilitary space programs on which both Army facilities are working—the Lunar Probe, IGY earth satellite, and assorted secret projects. But the 2000 civil service scientists and engineers at ABMA and a similar number of Cal Tech employes at JPL have continued on Army's payroll for work on such military projects as the Nike Zeus, Redstone, Jupiter, Sergeant, and Pershing missiles, reconnaissance satellites, and advanced high-thrust rocket engines.

The Army, in resisting NASA's plan, argues that loss of its key space scientists would hold back development of missile and space programs producing valuable military know-how as a byproduct.

LESS SCIENTIFIC FREEDOM

Opposition also comes from most of the scientists and engineers involved, and from many ABMA and JPL contractors who apparently want to continue under Army's operational control. Reasons for their opposition seem to be:

The individual scientists and engineers now have considerable stature as specialists in the Army, and have pretty much of a free hand to conduct research. If absorbed into the NASA, they fear their freedom of action would be restricted and their status downgraded.

The contractors, who have established connections with Army procurement officials, fret over the prospect of having to sell themselves once more to a new bureau. They also worry that NASA, in the tradition of its predecessor, the National Advisory Committee for Aeronautics, may put a new stress on using government-

owned facilities for R & D work, rather than farming out contracts to private labs. Actually, NASA's announced intention is to reverse NACA policy and contract out a considerable portion of its R & D activities.

NASA's claim to management control over ABMA and JPL is in line with the new agency's drive to control all nonmilitary, government-supported space research. Agency officials argue that technical direction over military-conducted projects is not enough for such centralized control, that actual operation of military facilities engaged in the projects is needed.

The law passed in July, setting up NASA to "conduct and coordinate" space research, authorizes the agency to assume control over military personnel and facilities. The agency recently absorbed the Navy's 150-man project Vanguard staff, formerly a part of the Naval Research Lab.

The Air Force which also has been forced to turn over administration of several important space projects to the new agency, has no facilities of its own, and is not involved in the new controversy. The Air Force has contracted out the bulk of its work to private facilities.

PRESIDENT TO DECIDE

President Eisenhower said that his decision on NASA will be guided by recommendations from the eight-man National Aeronautics & Space Council created by the July law as an advisory group to the President.

This council consists of Secy of State Dulles, Secy of Defense McElroy, AEC Chairman McCone, NASA Administrator Glennan, Dr. Allen T. Waterman, director of the National Science Foundation, James Doolittle, vice-president of Shell Oil and soon-to-be Board Chairman of the private Space Technology Laboratories, Wm. A. M. Burden, former Asst Secy of Commerce for Air, and Dr. Detlev Bronk, president of both the Rockefeller Institute for Medical Research and the National Academy of Sciences.

The council is scheduled to meet on Oct. 28. Odds are the NASA proposal will be approved. The most effective argument is this: Since the Army and the other services have now been virtually stripped of all space research work not directly tied to weapons system development, the workload at both ABMA and JPL has been considerably whittled down.

READER TO EDITOR

Salaries in Switzerland

To the Editor:

In your report on "Engineering in Europe" (Sept 1, p 32) you refer to the "Zurich Federal Technical University," "Zurich University," and "State University of Zurich." The official title is: "Swiss Federal Institute of Technology" (in German: Eidgenossische Technishe Hochschule, which could be translated as the "Swiss Technical University" in Zurich). Another point: You refer to the schools in Winterthur, Biel and Bergdorff (should read: "Burgdorf"). These are called "Technicum(s)" in German; the engineers coming from these schools are called "Techniker" (technicians). However, you cannot call these engineers "graduates" because the diploma they receive is not that for an academic degree. The night schools are called "Abendtechnicums." Further, there are 5 more Technicums in Switzerland: Fribourg, Geneva, Lausanne, Lucerne, Neucgatel.

With regard to starting salaries in Switzerland, the following figures might interest you: In general, salaries are between 30 and 50% higher than in Germany. The average pay for a worker is Sw. Fr. 3.10 in Switzerland (Germany Sw. Fr. 2.50) per hour; the average salary for an employe is Sw. Fr. 960 per month (Germany: Sw. Fr. 630).

The starting salary for an engineer (graduate) varies between $200 and 250. After 5 years of experience his salary will lie between $280 and 350; after 10 years' experience between $350 and 500. (The starting salary is thus roughly 50% higher than that in Germany) although later the difference is reduced to 20 to 30%. Of course, the salary paid to an experienced engineer varies between much larger limits than that paid to an engineer just starting.

—Raymond Shah
Zurich, Switzerland

Pressure-sensitive Materials

To the Editor:

In the article "Pressure-sensitive Materials," Sept '57, p 106, the author D. B. Clark, described a new material that changes its electrical conductance considerably (up to 100% or even more) when pressure or other outside forces are applied. This material, produced "by processing rare earths with zirconium tetrachloride," looked very promising for building cheap and tiny pressure transducers. We purchased samples of these transducers, and ran extensive tests in our laboratories. The results indicate they are not suitable for precise quantitative pressure measurements.

In summary, this is what we found: resistance changed discontinuously with continuously changing pressure (typical was a 10% step); jarring caused abrupt change in readings—as much as 50%; and readings tended to drift, even without disturbances.

Some of the sensitivity of the material seems to be caused by change in contact resistance between it and its metal contactor. This suggests a working principle similar to that in a carbon microphone. We later proved that a simple preparation of graphite powder was about as pressure-sensitive as the Clark material, and that thickness of the pressure-sensitive layer was not as important as the nature of the contact surfaces.

There are certainly many fields of science where exact amplitude of a measurement is not needed, but where order of magnitude and timing are important. Explosions, detonation waves, vibrations, accelerations, or any type of compression waves in solids, fluids, or gases can be measured with pickups made from this inexpensive material. Here the Clark type transducers may have definite advantages over other types.

—Herbert J. Bomelburg
Aberdeen, Md.

Misplaced Kiwi

To the Editor:

In the Sept 1 issue, p 23, you stated that the neuclear reactor Kiwi-A was named after an Australian bird. Gentlemen:

At Engineering you're a whiz, at Zoology a failure;
'Tis Kangaroo and Platypus in antipodean Australia.
The Koala and the Wombat, too, are peculiar to this free land.
But the flightless Kiwi can be found nowhere but in New Zealand.

—Geoffrey E. Page
Fabricated Allovs Co
Monticello, Ill.

• *Right you are about the Kiwi, he never left New Zealand.*
The Typesetter here is guiltless, for an editor used his free hand.
In the future we'll be sure our copy's ripe and polished.
For our staff has not just engineers but also an anthropologist.—**Ed**

Current Cars Spell Safety, Enjoyment

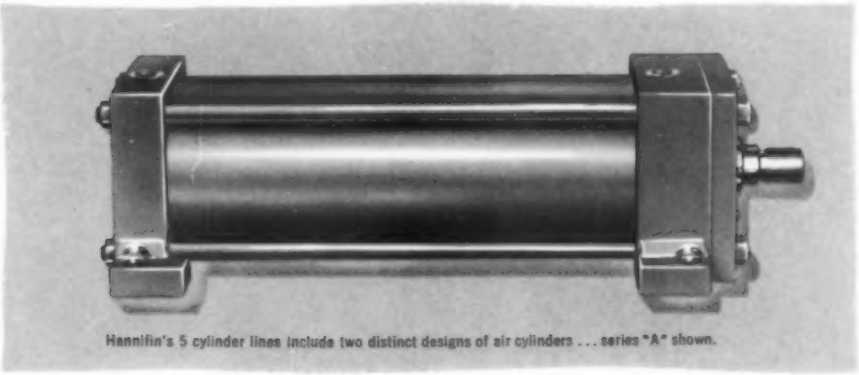
To the Editor:

Your brief editorial comment (Sept 8, p 2) that comparative tests between a 1929 model automobile and a new model showed "drivers were equally fatigued each night" are misleading. Even the most ardent anti-Detroit campaigner who can recall cars of that era would find it difficult to defend such a statement. A newspaper article titled, "Today's Cars Found Easier on Drivers," (Detroit News) describes tests run by DeSoto that proved some of the engineering advances in the past 30 years.

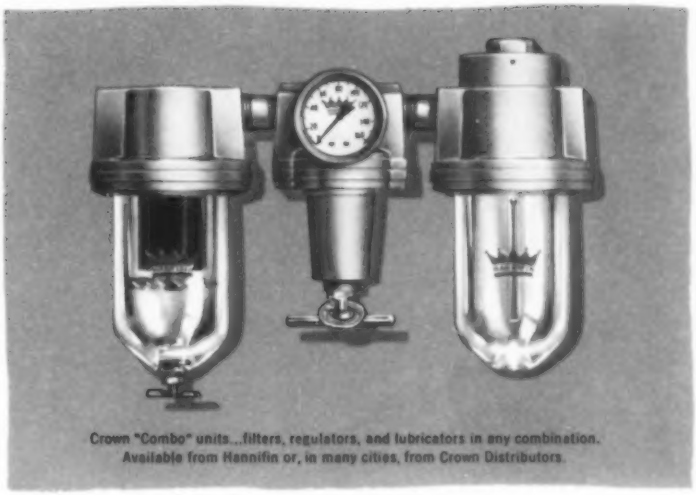
Six hundred miles of turnpike driving each day may get monotonous, but the automatic transmissions, greater visibility, high-speed cruising capability, and improved handling of late-model cars spell safety, enjoyment, and reduced fatigue to the motorist.

—R. W. Pauley
Royal Oak, Mich.

PARKER-HANNIFIN FLUID-SYSTEM COMPONENTS



Hannifin's 5 cylinder lines include two distinct designs of air cylinders . . . series "A" shown.



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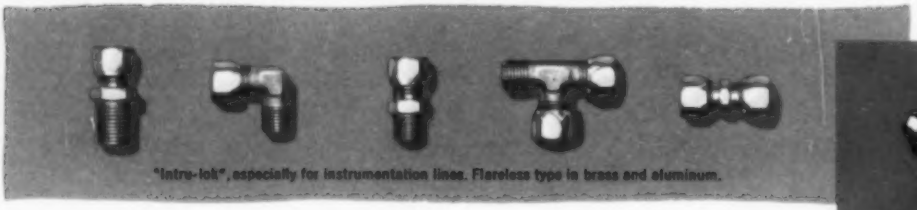
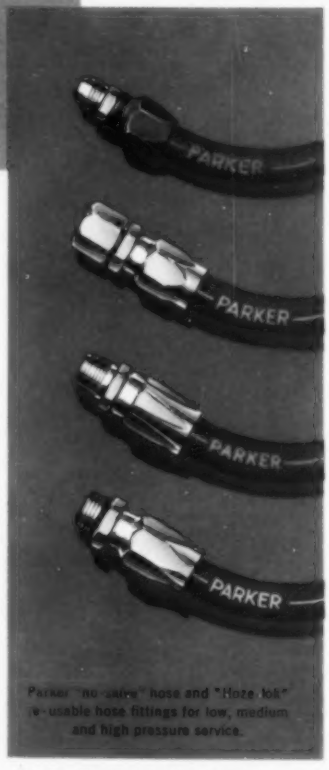
"Ferulok"®, the flareless type with the visible "bite", especially for heavy-wall tubing... in steel and stainless steel.

"Weld-lok" socket-type fittings, steel or stainless steel. Also "Braze-lok", in almost any metal.



"Intru-lok", especially for instrumentation lines. Flareless type in brass and aluminum.



Parker "no-skive" hose and "Hoze-lok" re-usable hose fittings for low, medium and high pressure service.

Only from Parker

such a wide range of fittings...so fast

If it's an industrial fitting, whether for tubing or for hose, Parker has it or can make it, in standard sizes in any metal.

Parker "Triple-lok" for flared tubing . . . Parker "Ferulok"® for heavy-wall tubing . . . Parker "Weld-lok" for high-temperature, high pressure lines. ("Braze-lok", our newest line, does not require an open torch, is for medium temperatures.) "Intru-lok", for copper, aluminum or plastic instrumentation lines, requires no flaring. Parker hose and "Hoze-lok" re-usable hose fittings require no skiving of the hose.

There's a Parker distributor near you, write us for his name . . . call him for Parker catalogs.

Parker Fittings and Hose Division
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"WEIRKOTE'S ZINC COATING STAYS SKINTIGHT. NO PEELING OR FLAKING—CAN ELIMINATE DIPPING OR PLATING AFTER FABRICATION!"

Q. Sure, but what happens on the tough jobs—like deep drawing or crimping?

A. You can work Weirkote right to the limit of the steel itself. And as I said, no peeling or flaking.

Q. Then where's the miracle? We tried galvanized before. And it struck out. Too much trouble, too much cost fixing it up after fabrication.

A. No miracle. It's just that Weirkote's made by the continuous process which integrates zinc and steel so that the toughest fabrication won't break down the bond.

Q. That means then that Weirkote can eliminate the need for plating or dipping to assure uniform corrosion protection for the most intricate part . . . is that the picture?

A. Yes, that's exactly the picture . . . and besides, Weirkote is now treated to inhibit wet storage (white oxide) stain.

Send today for free booklet that details the time- and cost-saving advantages of using skintight zinc-coated Weirkote. Write Weirton Steel Company, Dept. D-8, Weirton, West Virginia.

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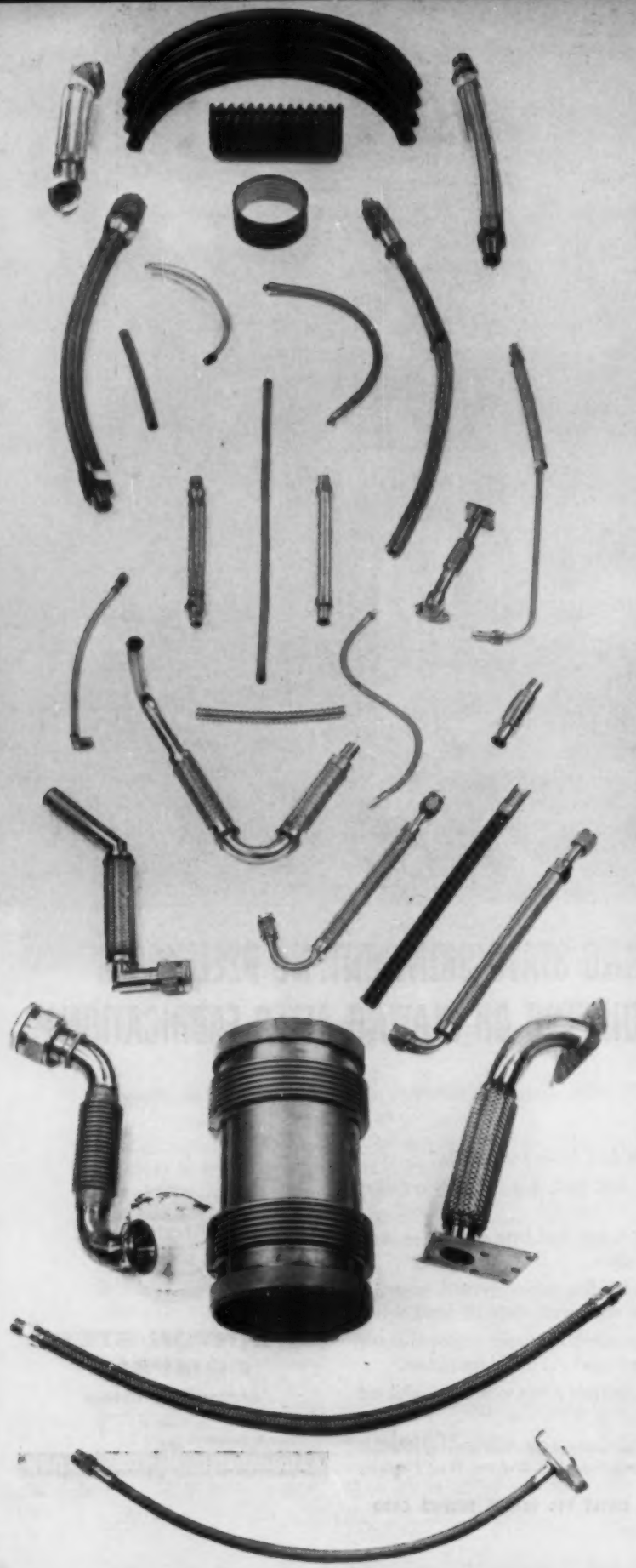

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For Design Engineers and Purchasing Agents:

These special catalog pages have been designed to acquaint you with the Howard line of fractional horsepower motors. Save them. They will serve as a handy reference to power sources for your future projects. Whatever your application, you can be sure of finding the right motor or variation in the Howard line. To date, over 100,000 specifications have been filled by the Howard motors shown. Many models meet military specs.

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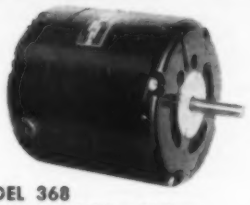
Ratings from 1/2000 to 1 H.P. • MOTOR PARTS SETS • MOTOR BLOWERS • GEAR REDUCTION UNITS

universal and direct current motors

MODEL 243
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—5000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.



MODEL 368
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 4-3/8.
LENGTH: 5-1/2 to 6-1/2.
H.P.: Continuous Series—1/2 @ 10,000 R.P.M.
Shunt or Compound—1/5.
Intermittent Series—1 H.P. @ 10,000 R.P.M.
Shunt or Compound—1/5.
SPEED: No Load Series—18,000 R.P.M.
Shunt or Compound—3500 to 12,00 R.P.M.
Full Load Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series 6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.

MODEL 29-500
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-5/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.

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Other Howard motors: UNIVERSAL & D.C. 1/200 to 1 h.p. • SHADED POLE 1/2000 to 1/8 h.p. INDUCTION 1/1400 to 1/8 h.p. • SERVO MOTORS • GEAR MOTORS • BLOWERS

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brush type motors • high speed
high starting torque • 1/200 to 1 h.p.

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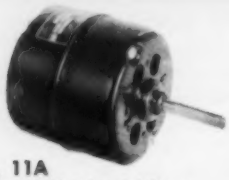


MODEL 11A

TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.825".
LENGTH: 3-9/16".
H.P.: Continuous 1/75.
Intermittent: 1/20.
SPEED: No Load Speed: Series — 15,000 R.P.M.
Shunt — 3500 to 12,000 R.P.M.
Full Load Speed: Series — 3000 to 10,000 R.P.M.
Shunt — 2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC-DC.
Shunt — 6 to 120V. D.C.
BEARINGS: Porous bronze self aligning type with felt oil reservoir.

MODEL 11-12

TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-25/32". 2-9/32" flat side.
LENGTH: 4-19/32".
H.P.: Continuous Series—1/15 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent: Series—1/6 @ 10,000 R.P.M.
Shunt—1/8.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—3500 to 10,000 R.P.M.
Full Load: Series—5000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with felt oil reservoir, or grease sealed ball.

MODEL 100

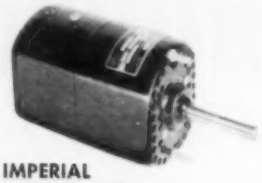
TYPE: Series or Shunt DC only.
DIAMETER: 2-5/16".
LENGTH: 3-3/32".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series— 1/13 @ 10,000 R.P.M.
Shunt—1/13.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt: 1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 106

TYPE: Series or Shunt DC only.
Diameter: 2-5/16".
LENGTH: 3.89".
3.85".
H.P.: Continuous: Series—1/35 @ 10,000 R.P.M.
Intermittent: Series—1/10 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
BEARINGS: Grease sealed ball bearings.

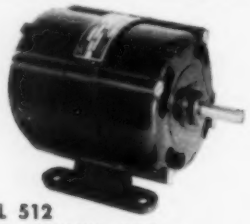
MODEL 200

TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.



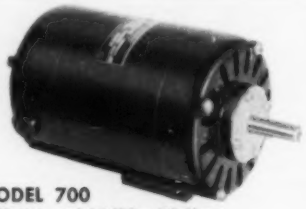
MODEL IMPERIAL

TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.725". 2-1/4". flat side.
LENGTH: 4-9/16".
H.P.: Continuous—Series—1/12 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent—Series—1/6 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze Self Aligning type.



MODEL 512

TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/5 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.



MODEL 700

TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.800".
LENGTH: 5-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 1100

TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

HOWARD INDUSTRIES INC., Racine, Wisconsin • Tel. Melrose 2-2731 • Teletype RAC344

APPLICATIONS by HOWARD

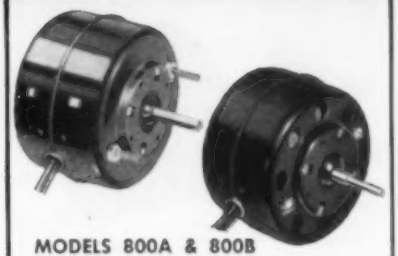
shaded pole motors

POWERED BY HOWARD

constant speed • no brushes • no commutators • no radio or TV interference • low starting torque 1/2000 to 1/3 h.p.

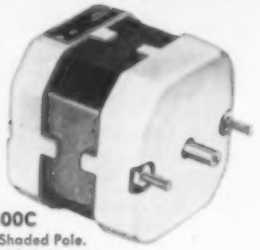
MODEL 300

TYPE: Two Pole Shaded Pole AC—3200 R.P.M.
WIDTH: 2-15/32". LENGTH: 3-7/8".
MAXIMUM CONTINUOUS TORQUE OZ. IN. (at 11/16" Stacking Length).
*1 R.P.M. 500 oz. in.
*150 R.P.M. 3.3 oz. in.
MAXIMUM INTERMITTENT TORQUE OZ. IN. (at 11/16" Stacking Length).
*1 R.P.M. 750 oz. in.
*150 R. P. M. 5 oz. in.
VOLTS: 12 to 115.
BEARINGS: Porous bronze sleeve bearings with oil reservoir.
*Torques at intermittent speeds are inversely proportional to speed.



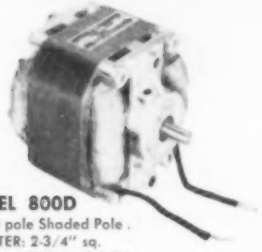
MODELS 800A & 800B

TYPE: 4 Pole Shaded Pole.
DIAMETER: 3-7/16".
LENGTH: 2-3/4" to 3-1/4".
ELECTRICAL SPECIFICATIONS:
3/4" Stack—Continuous Duty No Fan 1/300. Continuous Fan Duty 1/125.
1-1/4" Stack—Continuous Duty No Fan 1/200. Continuous Fan Duty 1/80.
BEARINGS: Porous bronze self aligning sleeve type with felt oil reservoir.



MODEL 800C

TYPE: 4 Pole Shaded Pole.
DIAMETER: 2-15/16" square.
LENGTH: 2-3/16" to 2-11/16".
ELECTRICAL SPECIFICATIONS:
3/4" Stack 1/125 H.P. fan duty* continuous
1-1/4" Stack 1/80 H.P. fan duty* continuous.
BEARINGS: Grease sealed ball bearings.
*With fan drawing air over motor. Variations in H.P. are available to meet application requirements.



MODEL 800D

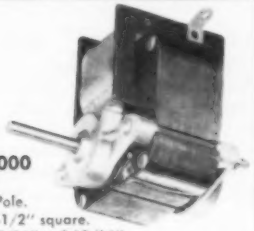
TYPE: 4 pole Shaded Pole .
DIAMETER: 2-3/4" sq.
LENGTH: 1-7/8" to 2-3/8".
ELECTRICAL SPECIFICATIONS:
3/4" Stack 1/125 H. P. fan duty* continuous.
1-1/4" Stack 1/80 H. P. fan duty* continuous.
BEARINGS: Porous bronze with felt oil reservoir and external oil hole.
*With fan drawing air over motor. Variations in H.P. are available to meet specifications.

MODEL 2800D DIE CAST CASE

TYPE: 4 Pole Shaded Pole.
DIAMETER: 3-3/4".
LENGTH: 4-5/8".
H.P. (at 1-1/2" Stacking Length): 1/40*.
SPEED (at 1-1/2" Stacking Length):
Full Load Speed—1500.
No Load Speed—1725.
STARTING TORQUE (at 1-1/2" Stacking Length): 10.0. OZ. IN.
BEARINGS: Porous bronze with oil reservoir, or grease sealed ball bearings.
*The above ratings are continuous duty, 55°C. rise in a 40°C. ambient, open ventilated motor with internal fan.

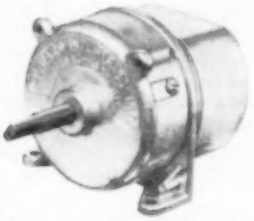
MODEL 2800S STAMPED STEEL CASE

TYPE: 4 Pole Shaded Pole.
DIAMETER: 3-9/32".
LENGTH: 2-3/16" to 3-1/16".
H.P. (at 1-1/2" Stacking Length): *1/40.
SPEED (at 1-1/2" Stacking Length):
Full Load Speed—1500.
No Load Speed—1725.
STARTING TORQUE (at 1-1/2" Stacking Length): 10.0. OZ. IN.
BEARINGS: Porous bronze sleeve type with large oil reservoir.
*The above ratings are continuous duty, 55°C. rise in a 40° ambient, with air delivery drawn over the open ventilated motor.



MODEL 3000

TYPE: 2 pole Shaded Pole.
DIAMETER: 2-1/2" square.
LENGTH: 1-15/16" to 2-13/16".
ELECTRICAL SPECIFICATIONS:
Type 3006—5/8" Stack—1/200 H.P.* Maximum Intermittent. 1/500 H.P.* Maximum Continuous Duty.
Type 3011—1-1/8" Stack—1/80 H.P.* Maximum Intermittent. 1/200 H.P.* Maximum Continuous Duty.
Type 3015—1-1/2" Stack—1/60 H.P.* Maximum Intermittent. 1/80 H.P.* Maximum Continuous Duty.
BEARINGS: Porous bronze sleeve type.
*With air drawn over motor.



MODEL 3000 WITH GEAR UNIT

TYPE: 2 Pole Shaded Pole.
DIAMETER: 3-7/16"
LENGTH: 3-5/8" to 4-1/2".
MAXIMUM CONTINUOUS TORQUE* 1 R.P.M. (at 1-1/2" Stacking Length): 45 in. lbs.
MAXIMUM INTERMITTENT TORQUE* 1 R. P.M. (at 1-1/2" Stacking Length): 120 in. lbs.
BEARINGS: Porous bronze sleeve type with oil reservoir.
*With external fan. Torques at other speeds from 1 to 400 rpm available upon request.

MODEL 4400

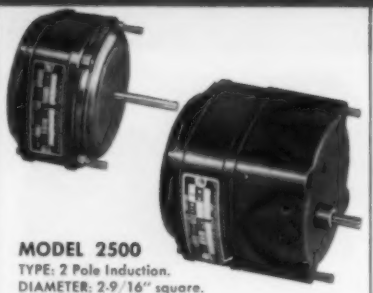
TYPE: 4 Pole Shaded Pole.
DIAMETER: 4-13/32".
LENGTH: 3-31/32" to 4-31/32".
H.P. (at 2" Stacking Length):* 1/11.
SPEED: Full Load Speed—†1500 R.P.M.
No Load Speed—1750 R.P.M.
STALLED TORQUE OZ. IN. (at 2" Stacking Length): 20.
*The above ratings are continuous duty, 55°C. rise in a 40°C. ambient, with air delivery over the motor.
†Also available in two speeds of 1500 and 1100.
‡Standard is 115 volts, other voltages available on request.

HOWARD INDUSTRIES INC., Racine, Wisconsin • Tel. Melrose 2-2731 • Teletype RAC344

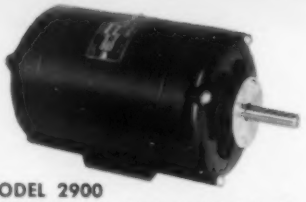
HOWARD induction motors

synchronous non-synchronous hysteresis torque servo types
1/1400 to 1/4 h. p.

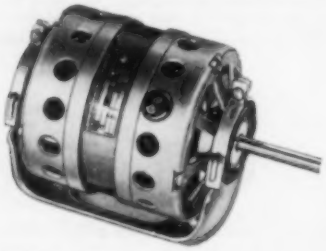
MODEL 2400
TYPE: 4 Pole Induction.
DIAMETER: 2-9/16" square.
LENGTH: 2-3/8" to 3".
SINGLE PHASE CAPACITOR MOTOR:
Maximum Torque oz. in.—1.
Full Load Speed R.P.M.—1150.
Bearings—RBC—Ball. RWC—Sleeve.
TWO PHASE MOTOR:
Maximum Torque oz. in.—1.5.
R.P.M.—1150.
Bearings: RBT—Ball. RWT—Sleeve.
BEARINGS: Porous bronze sleeve type with oil reservoir, or grease sealed ball bearings.



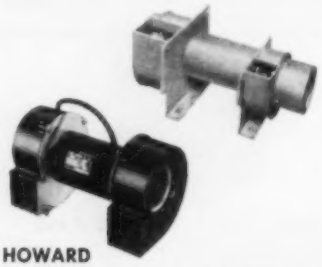
MODEL 2500
TYPE: 2 Pole Induction.
DIAMETER: 2-9/16" square.
LENGTH: 1-7/8" to 2-3/8".
SPEED: *2250 to 3600 R.P.M.
H.P.: .1/300 to 1/1400.
MAXIMUM TORQUE OZ. IN.: *1.6 to 3.5.
BEARINGS: *Ball or sleeve.
*Dependent on type of motor used; i.e. Non-Synchronous Capacitor Motors, Torque Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors.



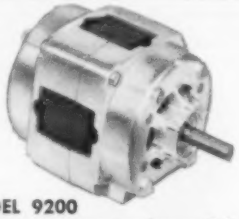
MODEL 2900
TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-5/16".
LENGTH: 4-25/32" to 5-21/32" ball bearing. 5-5/16" to 6-3/16" sleeve bearing.
H.P.: *1/70 to 1/15.
FULL LOAD TORQUE OZ. IN.: *10.0 to 30.
BEARINGS: Bronze sleeve type with oil reservoirs, or permanently lubricated sealed and shielded ball bearings.
*Dependent on type of motor used; i.e. Non-Synchronous Capacitor Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors. Torque Motors.



MODEL 3700
TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-7/8".
LENGTH: 5-1/16" to 5-11/16".
H.P.: *1/25 to 1/7.
STARTING TORQUE: *13 oz. in. to 30 oz. in.
BEARINGS: Porous bronze type with oil reservoir.
*Dependent on type of motor used, i.e. Normal Induction Motor, Hysteresis Synchronous Motor.



HOWARD
STANDARD BLOWER ASSEMBLIES
Howard manufacturers blower assemblies for many applications. Illustrated above are two typical Howard blower units currently used for electronic applications. Detailed information will be supplied on request.

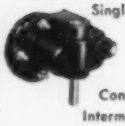


MODEL 9200
TYPE: Induction, torque, synchronous 2, 4, 6 or 8 poles, 25 to 60 cy single (capacitor) two or 3 phase.
HP: 1/250 to 1/50 continuous or intermittent duty.
R.P.M.: 900 to 3600.
DIMENSIONS: 2-7/8" x 2-7/8" by 4-1/32" to 4-13/32".
MOUNTING: Pad, resilient ring, face extended bolts.
BEARINGS: Porous bronze sleeve, (ball bearings available at request).

gear reduction units

MODEL A-1
Single Reduction, Open
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%

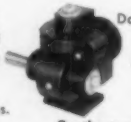
MODEL A-3
Double Reduction, Open, With Mounting Pad
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 30%



MODEL A-4
Single Reduction, Closed
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%

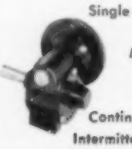
MODEL A-5
Double Reduction, Closed
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 10 in. lbs.
Intermittent Duty: 20 in. lbs.
Efficiency: Max. 30%

MODEL A-6
Single Reduction, Closed
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 12 in. lbs.
Intermittent Duty: 25 in. lbs.
Efficiency: Max. 65%



MODEL A-7
Double Reduction Closed, Heavy Duty
Maximum Ratio: 2600:1
Minimum Ratio: 21.5:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 50%

MODEL A-12
Combined Worm and Spur Gears
Maximum Ratio: 525:1
Minimum Ratio: 6.7:1
TORQUE
Continuous Duty: 100 in. lbs.
Intermittent Duty: 250 in. lbs.
Efficiency: Max. 50%

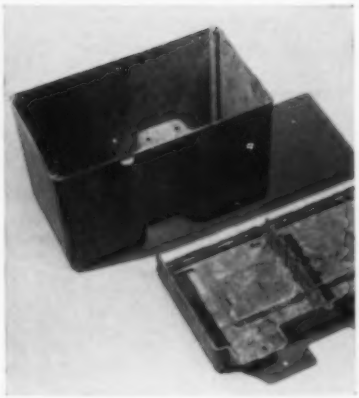


MODEL A-26
Single Reduction, Closed Heavy Duty
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 80%

Full information is available on all motors illustrated. Write for complete data.
HOWARD INDUSTRIES INC., Racine, Wisconsin • Tel. Melrose 2-2731 • Teletype RAC344

PRODUCT-DESIGN MEMOS FROM DUREZ

High-impact phenolic | **Automatic molding**
Phenolic for appliances



Flying saucer?

This plastic housing helps airmen find out what's cooking on the roof of the world.

It's part of a radiosonde, a device that has sparked many flying-saucer reports.

Dropped from a high-flying weather reconnaissance plane over an ocean or arctic ice, the radiosonde flips its plastic lid, releasing a parachute.

The ballooning chute yanks an antenna line out of the case. Then, as the device drifts groundward, it broadcasts a code report on air temperature, pressure, and humidity every six seconds.

Picked up by radio men, these signals enable the Air Force to piece together accurate forecasts of flying weather over remote frontiers.

The snap-off housing is molded of *Durez 16771 Natural*, selected for its impact strength and its ability to stand extremes of temperature and humidity.

In sharp contrast to the mass production of phenolic parts, this use of Durez suggests its ability to meet *your* out-of-the-ordinary requirements.

If you'd like technical data on 16771 Natural, check the coupon. For information on other special-purpose phenolics, write us, outlining the problem.

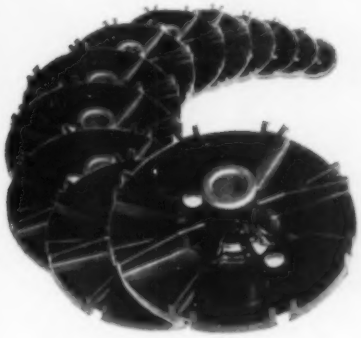
Big job, big saving

What's hot in phenolics? *Automation.*

Automatic molding of a 4¾-inch diameter water-pump impeller for new Ford cars, trucks, and tractors has made possible a switch from cast iron to phenolic —with substantial reductions in weight, production time, and cost.

The impellers are molded 12 at a shot on the largest capacity compression molding press ever to operate on fully automatic cycle.

The material selected for the impeller is a Durez phenolic impervious to antifreeze and antirust solutions, combining moisture resistance with dimensional stability in high degree.



Thinking big? You'll find there are many ways in which mass-production molding and Durez phenolics can team up profitably for you. The versatility and exceptional batch-to-batch uniformity of these compounds assure best possible results on highly automated production lines.

Ask your molder or your Durez sales representative to suggest how you can put these advantages to work in your products.

Durez and the coffee-break

Appliance makers can tell you that wherever coffee perks, bubbles, or pours into a cup, there's likely to be a Durez phenolic close by.

Electrical components, handles, knobs —these are just a few essentials of a coffee-break, in which Durez molding compounds play an unassuming part.

A prime requisite for this sort of assignment is the ability of phenolic to resist coffee stains and chemical deterioration. The appliance designer also looks for:

- excellent surface finish
- good dimensional stability
- coolness to the touch
- crack resistance when molded around large inserts

If *you're* looking for properties like these, you can find them all in *Durez 791 Black*. They're exemplified in the component shown here, an electrode assembly for a king-sized coffee maker and dispenser.

For more facts on versatile 791 Black, check the coupon.

For more information on the Durez materials mentioned above, check here:

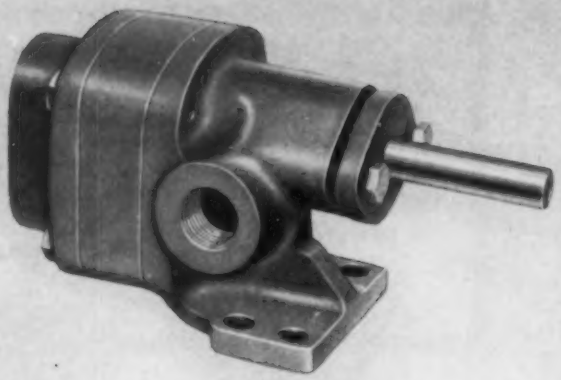
- ☐ High-impact Durez 16771 Natural—data sheet
- ☐ Phenolic molding compounds—descriptive bulletin
- ☐ General-purpose Durez 791 Black—data sheet

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

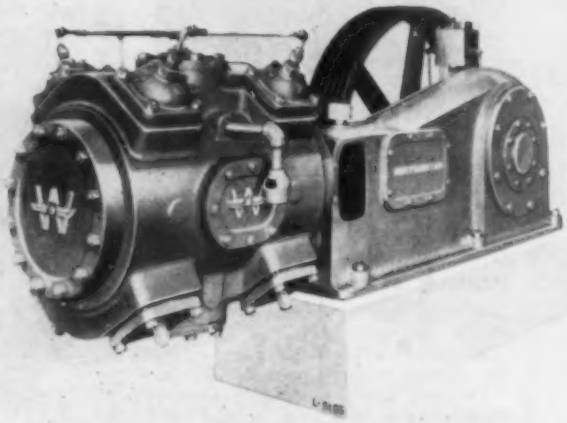
PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
1510 Walck Road, North Tonawanda, N. Y.

Monobloc Rotary Pump



Rotary Pump

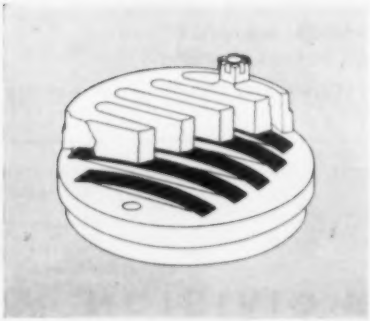
Monobloc Centrifugal Pump



Water-cooled Compressor

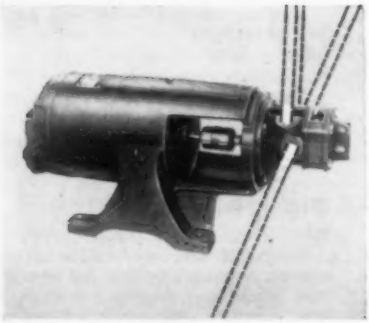
On any pump or compressor you choose, only Worthington gives you these

EXCLUSIVE



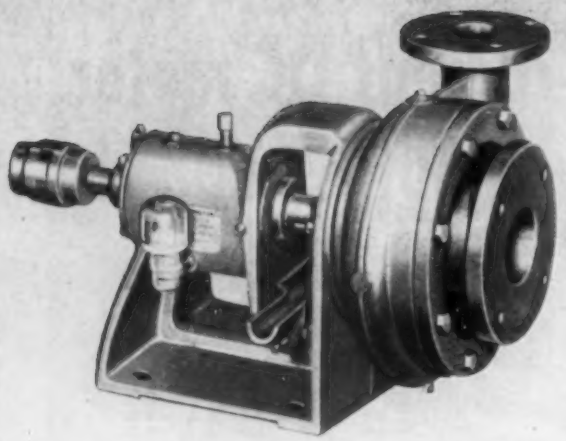
Feather Valve Lightest, fastest-acting compressor valve available. Works with no impact, is all but indestructible, and has an amazing record of long life with negligible maintenance costs.

70,480 Combinations Completely standard and interchangeable components let you save up to 50% on spare parts inventory, permit you to design and build over 70 thousand "special" pumps using but 6 SESC pumps.

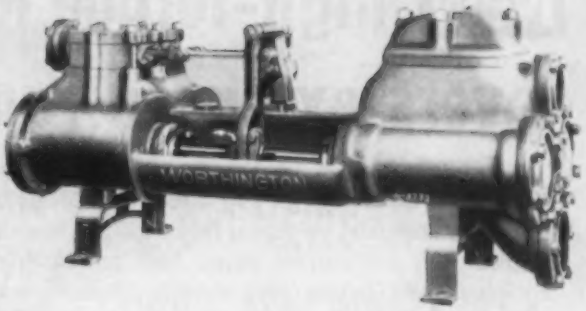


Monobloc Rotary Pump Eliminate alignment problems, simplify layouts by choosing up to 28 different ways to hook up pump piping. Saves you time, materials, is less expensive than separate pump, motor and baseplate.

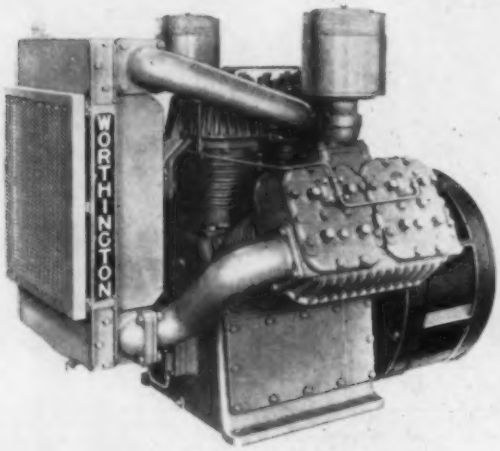
CIRCLE 121 READER SERVICE CARD



Chemical Centrifugal Pump



Steam Pump



Radial Air-cooled Compressor

Balanced Angle Air-cooled Compressor

DESIGN ADVANTAGES

Designing and manufacturing outstanding products has been a success story typical of Worthington for 118 years. Foremost examples of this leadership and engineering skill are the exclusive design advantages of Worthington pumps and compressors. Three of the most important are illustrated at left: Feather Valves*, Monobloc Rotary pumps, and the unmatched flexibility achieved through standardization of the SESC (Standard End Suction Centrifugal) line.

Worthite*, Worthington's *super* stainless steel, has set new corrosion resistance standards for chemical pumps. Worthington air-cooled or water-cooled compressors include carefully balanced operating parts, low piston speeds, and liberal cooling surfaces on cylinders and intercoolers or aftercoolers. Increased performance and accessibility of portable and balanced angle compressors and the money-saving benefits of easy installation and low maintenance of the entire pump and compressor line lend further testimony to Worthington engineering competence. But whatever your application, your design problem, Worthington can help you.

Your nearby Worthington representative stands ready to explain the many advantages of one *complete* Worthington pump and compressor line to you. For more information on how to improve your product's performance or reduce engineering design and expense, contact him now. Or write for bulletin, Worthington Corporation, Section 104-7, Harrison, N.J. In Canada, Worthington, Ltd., Brantford, Ontario.

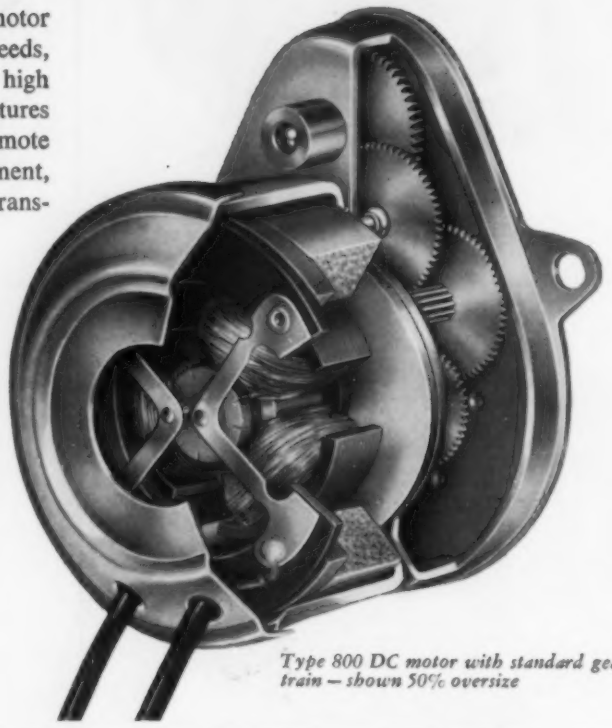
WORTHINGTON

*A high-nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U.S. Pat. Off.

CIRCLE 122 READER SERVICE CARD

New high-torque low-current DC motor covers extended range of output speeds

The new Cramer Type 800 direct current motor offers an unusually wide range of output speeds, coupled with low current drain, high torque, high efficiency, and excellent speed stability. These features make it the ideal choice for timing devices, remote control equipment, recorders, signalling equipment, communications gear, displays, flashers, chart transports, and many other products.



Type 800 DC motor with standard gear train — shown 50% oversize

Wide Performance Range

Depending on requirements of speed, torque, and voltage, the rotor is wound to produce a basic motor speed of 960 to 3000 rpm. A gear train then reduces this to the speed required at the output shaft. Low rotor speeds result in lower current drain at all speed-torque combinations, but limit the torque available at the higher output speeds. Higher rotor speeds require a somewhat higher input current, but greatly increase the torque available at the higher output speeds.

The Table at lower right illustrates this flexibility of design, with a few examples from the virtually unlimited range of performance characteristics which it provides. Where very low input current is required, and the supply voltage does not exceed 12 volts, the use of the low-speed rotor will provide 30 oz. in. at speeds below 3 rpm and 0.5 oz. in. at 200 rpm. The higher speed rotors meet the requirements of higher input voltages, and provide greatly increased torque at the higher output speeds with only a moderate increase in current drain. The high-torque motor has the additional advantage of speed stability within 10% from no-load to full-load, at speeds below 5 rpm.

The examples given in the Table are for illustration only. By correct choice of rotor winding and gear ratio, an unlimited number of operating specifications can be established throughout the entire range shown. The motor is also available without gear train, for output torques of 0.1 to 0.6 oz. in. at speeds up to 3000 rpm.

OUTPUT SPEEDS WITH GEAR TRAINS	960 RPM ROTOR LOW INPUT CURRENT *(3 to 12 volts DC)*		3000 RPM ROTOR HIGH OUTPUT TORQUE *(3 to 30 volts DC)*	
	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.
2 rpd	.16	30	.....	.....
1/6 rpm	.16	30	.56	30
3 rpm	.35	24	.64	30
10 rpm	.35	8.5	1.04	30
30 rpm	.35	3.0	1.72	21
60 rpm	.35	1.5	1.72	12
80 rpm	.35	1.1	1.72	8.5
200 rpm	.35	.5	1.72	3.5
900 rpm	.....	.....	1.90	.8

Typical Performance of Type 800 DC Motors for Minimum Input Current or Maximum Output Torque

Specifications

SPEEDS — 2 rpd to 900 rpm with gear train, 960 rpm to 3000 rpm without gear train.

TORQUE — 0.1 to 0.6 oz. in. without gear train, and to 30 oz. in. with gear train.

CURRENT DRAIN — as low as 30 milliamperes, depending on voltage, load and speed.

VOLTAGES — from 3 to 30 volts DC.

REVERSING OPERATION — with negligible speed difference, because of special motor design.

GEARS — precision-hobbed throughout, totally enclosed and with sealed-in lubricant.

For your free copy of informative Bulletin PB-800, write:

CRAMER CONTROLS
CORPORATION
Box 7, Centerbrook, Connecticut

DESIGN FREEDOM STARTS WITH ALCOA ALUMINUM

Alcoa Offers Screw Stock In Specific 12-ft. Lengths, No Increased Cost
PITTSBURGH, Aug. 30, 1958—Aluminum
Alcoa Adds Alloys 2024-T4, 6061-T6 to Screw Stock Schedule
PITTSBURGH, Nov. 11, 1957—Alu-
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Alcoa Extends Range Of Chamfered Ends At No Extra Cost
PITTSBURGH, Jan. 21, 1957—Alumi-
num Company of America today increased
Alcoa Stress Relieves Screw Machine Stock
PITTSBURGH, July 8, 1957—Stress-relieved
screw machine stock offering better machining charac-
Alcoa Backs Distributor Stock With Mill Inventory
PITTSBURGH, March 18, 1957—Alu-
pany of America announced today
Alcoa Buys Turnings And Borings
PITTSBURGH, April 1, 1958—Alumi-
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ALCOA
ALUMINUM
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

THE BIG NEWS IN SCREW MACHINE STOCK COMES FROM ALCOA

We think there's more to service than making the best screw machine stock readily available in any quantity. ALCOA is consistently a step ahead with new economies, new design and production conveniences. Here are six ALCOA "firsts":

- Specific 12-ft lengths at no extra cost—all screw stock in rounds to 2¾ in. dia. and hexagons to 2 in. across flats.
- Alloys 2024-T4 and 6061-T6 added to Screw Stock schedule. This means important economies through the addition of sizes formerly nonstandard which are now standard and groupable for price advantage.
- Chamfered ends at no extra cost for all rounds and hexagons up to 3 in. in alloys 2011-T3, -T8, 2017-T4, 2024-T4, 6061-T6.
- Full screw stock size range of alloys 2017-T4, 2024-T4, 6061-T6 stress relieved for improved machining characteristics.
- Mill inventory to supplement distributor stock and cover emergency requirements of mill customers.
- ALCOA agrees to purchase up to 60 per cent of customer's turnings and borings generated from alloys 2011-T3, 2017-T4, 2024-T4 and 6061-T6.

These and other reasons have prompted designers and production engineers of leading industries to switch to ALCOA® Aluminum Screw Machine Stock. The whole story, with direct quotes, is in three new ALCOA booklets—yours for the asking. Use the coupon.

Aluminum Company of America
865-K Alcoa Building, Pittsburgh 19, Pa.

Please send your case-history booklets containing quotes from leaders in industry on why they buy from Alcoa.

Name_____

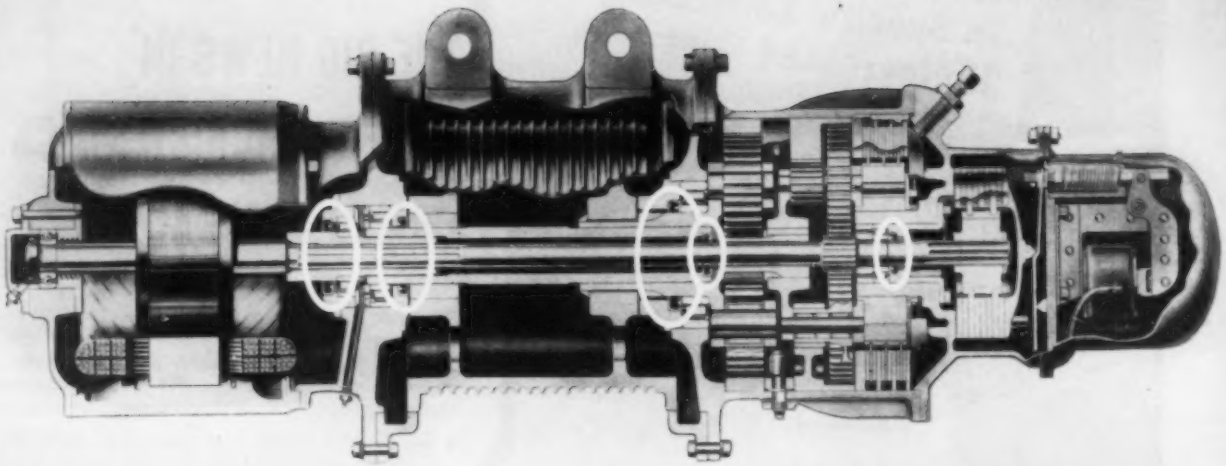
Position_____

Company_____

Address_____

City_____ Zone____ State_____

MORE ABOUT THE GARLOCK **2,000**



General-purpose KLOZURE Oil Seals (Model 63 cutaway right) afford complete protection at important bearing locations (circled above) on the Shepard-Niles "Liftabout" Hoist.

Garlock Klozure* Oil Seals

assure durable, dependable performance on tough sealing jobs

Friction and bearing wear, hazardous to any industry, are especially harmful in materials handling. That's why Shepard-Niles and other leading crane and hoist manufacturers specify Garlock KLOZURE Oil Seals for complete bearing protection. Shepard-Niles "Liftabout" is typical of how Garlock KLOZURES not only exclude dust and foreign matter from bearings but also retain the important lubrication—both of which add to greater dependability during rugged hoist operation.

Designing Garlock KLOZURES into your equipment protects bearings with oil seals that are durable, economical, and easy to replace. Garlock KLOZURES can be applied on low, medium, or high speed service. Whether your application is general-purpose in nature, or there's a specific job to be done, Garlock has a KLOZURE design for you.

KLOZURES are another of the Garlock 2,000 . . . two thousand types of packings, gaskets, and seals for every need. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative.

Call him or write for KLOZURE Catalog 20.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products.

PERSPECTIVES

in design and development . . .

Atomic Energy and the Law

To David Shea Teeple, the legal problems that face atomic energy are myriad . . . and more will arise in the near future. What is worse, Teeple feels, is that in many instances these legal problems have not even begun to be explored. Mr. Teeple served two years as assistant to Lewis Strauss, then Chairman of the Atomic Energy Commission, and before that was Deputy Director of the Joint Committee on Atomic Energy that handled the legislation resulting in the Atomic Energy Act. He is now a consultant on atomic energy to industry and several committees.

Concerning radioactive-waste disposal, for example, he feels that we have not set up adequate standards for the disposal of relatively small quantities of highly radioactive wastes or large amounts of low-level radioactive wastes. All we have done about high-level wastes is plan long-term storage that would allow time for the radioactivity to decay. And it is always possible, Teeple says, that the storage tanks would rupture: "A state like Nebraska, with the largest underground water supply in the US, might well contemplate the effects of radiation contamination of these underground waters. Is the gain (if there is any) from atomic reactors for electricity worth the risk?" By 1962 we will have to chemically process and dispose of one ton of radioactive wastes daily.

"Where," asks Teeple, "do the limits of liability lie for the radioactive-wastes processor?—when the material has been reduced in concentration to the standard of the AEC; when it has left the property of the processor; when it has been buried in the ground; carried down-stream or emitted into the air? What state regulations are necessary to control such disposal? Who should control this, and how much insurance is necessary?"

How Much Insurance?

Operators of reactor facilities are required to carry indemnity insurance in varying amounts, depending on the reactor's power level, the amount of enriched nuclear materials, the location of the reactor with respect to population, etc. Based on these requirements, the maximum insurance that any privately operated facility must take out is $60 million. The rest of the coverage in event of an accident is authorized by Public Law 85-256; it provides Government indemnity insurance up to $500 million per incident. One requirement is that the licensee take out the $60-million policy before the Government insurance can take effect.

This is like a $50-deductible automobile insurance policy. But many state agencies such as universities, hospitals and state-supported research institutions are immune from tort liability. Also, it is illegal in many states for these agencies to buy liability insurance. And, under the Federal Tort Claims Act, it is debatable whether many Federal agencies can further waive the sovereign immunity of the US Government, or legally purchase atomic liability insurance, Teeple says.

To find one way out of this legal entanglement, Congress, in August, passed a law that allows nonprofit educational institutions to be covered by the Government's $500-million protection without carrying indemnity insurance of their own. "But," Teeple says, "this still leaves a legal 'no-man's land' as to the responsibility for the first $250,000 of liability, because the Government will not go to court for less than this amount.

"To further complicate the picture," he adds, "the AEC Indemnity Act only provides coverage for 'facilities' (reactors and allied labs), and not for fabricators, processors and carriers." —Paul Anderson

←CIRCLE 125 READER SERVICE CARD

ND FACTS

TINY SIZE...

TREMENDOUS IMPORTANCE!

New Departure has many years of experience in the manufacture of ball bearings to the finest ultra-precision tolerances. And . . . New Departure uses the most advanced equipment for research, development and production in making a full range of bearings of precision instrument classification. A new catalog, including miniature sizes, plus additional information helpful to you in design problems sent on request. Write New Departure, Division of General Motors, Bristol, Conn.

ASK FOR CATALOG P.I.B.

FULL SIZE	BORE B		DIAMETER D		WIDTH W		BALLS		CORNER RADIUS r (To Clear)
	FRACTION	DECIMAL	FRACTION	DECIMAL	FRACTION	DECIMAL	NO.	DIAMETER	
	3/64	.0469	5/32	.1562	1/16	.0625	5	1/32	.005
		.0550	3/16	.1875	3/64	.0781	6	1 mm	.005
	5/64					.0937	5	1/16	.006
	3/32					625	8	.025	005
	3/32						6	1/16	
	1/8							1 m	
	1/8								
	5/32	.15							
	3/16	.1875							.005
	3/16	.1875	3/8					mm	.006
	1/4	.2500	3/8	.3750					.006
	1/4	.2500	1/2	.5000	1/8	.1250	*12	*1 mm	.006

GM FORWARD FROM FIFTY

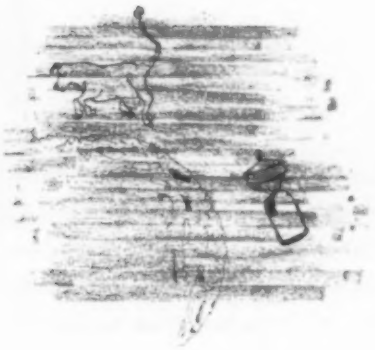
NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering **HORIZONS**

October 27, 1958



THE THRUST OF CURIOSITY

When you were very young, the moon was in turn a hurdle for a cow, green cheese, a home for a man that was all face, and something you cried for. But for this generation it is merely a target, and one that has been attained any number of times in story and song.

Thus, when Pioneer left earth's atmosphere last weekend and soared 75,000 miles into space, most of the younger fry were not surprised. As one editor's 7-year-old put it "What's wonderful about that?" She'd seen it done every evening or so on television.

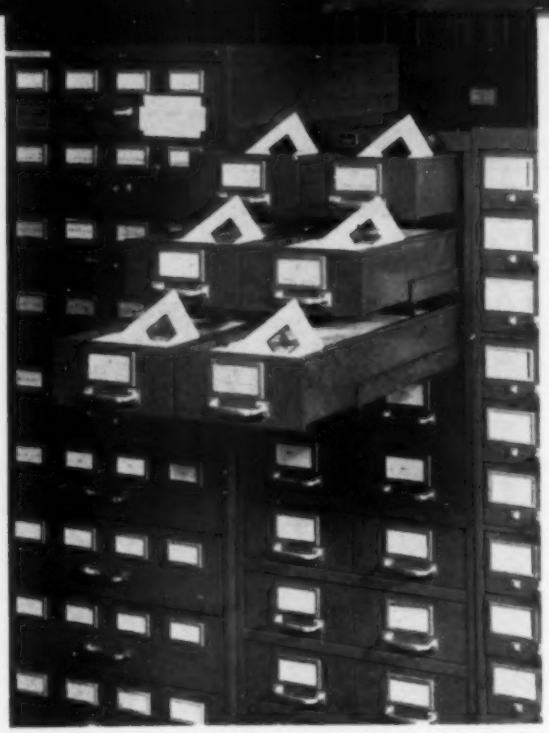
For three hundred years, at least, man has talked of the moon as a goal. Only a year ago, Sputnik I orbited and brought the moonshot into the realm of possibility. Now that we've orbited seven man-made satellites at heights to 2500 miles, and fired a rocket to an estimated 4000 miles, a shot 20 times that far is taken in stride.

For the first time, man has probed beyond his atmosphere, but only the scientists and engineers are impressed. Some 30 intricate mechanisms functioned perfectly in proper sequence. Some thousands of parts withstood the test for which they were designed. As a result, the most complex rocket ever made by man went into outer space. A 3½° error made by an auto-pilot guiding the first stage cost us the few hundred miles of velocity that would have made target—the impossible become commonplace again. Next month, on our third try, we may do it. The man in the street will not be surprised, or very much impressed, as long as we beat the Soviet rocketeers.

Thus has it ever been. The madmen who conquered mountains "because they were there," the visionaries who sailed west from Europe in cockleshells, the wizards who "fooled with" everything from fire to the atom—all were first laughed at, then hailed, then forgotten. Most of us expect the impossible to be achieved; we almost expect it as our due from some superior being, just as a baby soon learns to expect a parent to provide anything for which he cries.

Would it were so simple! Thousands of man-weeks must go into each such achievement, thousands of intelligent guesses must be made, thousands of long chances must be taken. Motivating it all must be the thrust of curiosity, the undying drive of a few men to stand where no man has stood before—be it Darien, the Indies, Everest, the moon, or some star yet unnamed.

And, out there, there may be beings with a similar thrust of curiosity about us.



Compact storage . . .
of microcopies is dramatically shown here. Open drawers contain 15,000 engineering drawings mounted in aperture cards.

Overflowing files of engineering drawings boost costs and fight the engineering staff for working space. Here's how miniaturization can solve such supervisory problems. And the job also becomes easier for the engineer himself when . . .

MICROFILM
pushes drawings aside

WALTER J LOCKE, Bell Telephone Laboratories

It is obvious enough that copying your engineering drawings onto microfilm will save storage space. But what does it cost to miniaturize the drawings, reproducibles and prints? What new equipment does the changeover require? What operational advantages will be gained?

These were some of the questions Bell Telephone Laboratories Inc hoped to answer for its three major plants when a trial quantity of 15,000 drawings were microfilmed at the Murray Hill, NJ, location in 1956. The results were so encouraging that operations have been expanded and a new trial–which amounts to a pilot installation–is now underway.

Anticipated Gains

Although this is simply a trial, and is as yet incomplete, our experience so far indicates many savings and associated advantages can be expected:

- Microfilmed copies can be enlarged and studied directly on a reader. This means fewer prints are made, and gone is the need to keep a supply of them and full-size reproducibles in stock. Also, prints are smaller than the original drawing, cutting costs of paper and mailing.

- There will be a considerable reduction in the number and variety of storage cabinets as well as some reduction in standard print-production equipment. Number of desks and worktables may also be cut.

- Savings in space are very great. Vast areas of cabinets for storing drawings, reproducibles and prints can be condensed into a very small space. Further savings can be expected because housecleaning is encouraged and facilitated during changeover.

- Many file-maintenance operations are eliminated or simplified; better service is supplied by fewer people.

- A disaster file and microfilm copies of obsolete drawings for record can be maintained economically.

Microfilm drawings also please the engineer. Prints of worn or dirty tracings, via microfilm, are of better quality because the camera photographs only the face of the drawing, not subsurface stains. Bulky tracings no longer compete for desk space. The film itself represents a small, convenient package of information; the print, smaller than original tracing, is easier to work with. Both are more compactly stored in the engineer's desk Orders for prints or duplicate films can be filled faster. If the engineer only wants an isolated piece of information from one drawing or several drawings, he can get it from a handful of film copies and a portable viewer.

The second test

In the expanded trial, 100,000 active drawings in the Murray Hill file are being photographed on 35mm film.

Before microfilm . . .
print storage required row upon row of file cabinets. Installation of microfilm program and incidental house-cleaning freed space shown here, occupied by 5-drawer file cabinets and shelves.

So is the file of inactive and obsolete drawings–about 150,000. Largest drawings in the file are 34 by 44 in. and tests showed these could be reduced to 35mm, the best space-saver, without noticable loss of detail. Though this means a reduction ratio reaching 30 diameters, recent advances in the microfilm field allow such drastic reductions to be made successfully.

After the inactives are microcopied, the original tracing is destroyed. Master rolls of film, after being checked for quality, are duplicated by the diazo process to give a second roll. The master roll goes to storage as the company's legal record; second roll is cut into frames, put in individual transparent envelopes along with the existing 3 x 5 cards already used for record purposes. Transparent envelopes mean no additional writing is necessary to identify the microcopy. Reference to these inactive drawings is infrequent, but when necessary, film can be viewed on an enlarger or processed, like active drawings, into extra prints.

The active file

Microcopies of active drawings receive somewhat different mounting. The silver negatives on the master roll are carefully inspected for quality, cut into individual frames, and mounted in apertured EAM (Electric Accounting Machine) cards. These are standard size (7⅜ x 3¼ in.) but with a hole cut to take one frame of 35 mm film–held in the card with pressure-sensitive tape that increases thickness of the card no more than 0.001 in.

Several other ways of unitizing microphotographs are being used in industry but this method was chosen because: (a) indexing information can be printed at less cost than if hand-written or typed, (b) duplicate cards can be made economically, (c) cards can be machine-verified, sorted and listed, (d) card stock is tough and uniform, having been developed for machine-tabulation installations, and (e) because punched-card equipment is used rather generally throughout the military services and industry, it is reasonable to anticipate that apertured EAM cards will quickly become the accepted standard.

These cards are filed progressively as they are produced and immediately become available to the engineer. When he orders a miniaturized drawing, a clerk makes a duplicate film card from the master card. Its second-generation film is, in effect, a throw-away microcopy of the drawing. Engineers can study an enlarged image of the film on readers supplied at convenient locations. They needn't come to the file. A phone call will put a duplicate film card in the mail in a specially marked envelope that assures fast delivery.

Blowback prints

When enlarged prints are required, either the master film card or a duplicate can be used on the enlarger-printer at the file. Experience thus far indicates that processing such print orders will be at least as fast as for diazo contact prints.

It is anticipated that there will be considerably less demand for prints, (presently some 700 to 800 per day) when film cards and readers are made available. We have not yet had sufficient experience with suitable readers to determine how far this reduction can go. Certainly, one out of four prints will no longer be required; and as engineering and shop personnel become accustomed to using readers, need for prints will be further reduced. Where an isolated piece of information–a dimension or part number–must be read from the drawing, film cards are quicker and more economical than full-size prints.

THE NECESSARY EQUIPMENT

Much expensive equipment is needed to operate an extensive microfilm system properly. All the necessary equipment has not yet been installed at Murray Hill, but several key items have been in use for many months. When investigating and selecting equipment, several factors must be considered to assure a practical, well-integrated system.

Camera

For microcopies going into aperture cards, the camera must be designed for unperforated 35mm film and have an automatic film advance of two inches per frame. This allows cutting film to aperture size. Also, the camera should give all of the standard reduction ratios. An exposure control will give constant background density when drawings have a variety of light-to-dark and clean-to-dirty backgrounds. Most important, the lens system should be able to bring the entire working field into sharp focus, resolving finest lines on the original and faithfully reproducing them with good contrast and negligible distortion.

There are two types of 35mm cameras: flat-bed sta-

COMPARISON OF ESTIMATED COST PER PRINT (including labor)

Size of Original, in.	Reproduction Cost, $					Print Size [a] As Reproduced from Microfilm, in.
	Blue or B-W Contact Print (full size)	Projection Reproduction from 35 mm Microfilm				
		Electrostatic Print		Photographic Print (Stabilized Process)	Diazo Print	
		Med. Vol, Hand-feed	High Vol, Auto.-feed			
8½ x 11	.05	.07	.04	.15	.07	8½ x 11 [b]
11 x 17	.08	.11	.07	.25	n.a.	11 x 17 [b]
17 x 22	.15	.11	.07	.25	n.a.	11 x 17 [c]
22 x 34	.30	.20	.12	.46	n.a.	17 x 22 [c]
		.11	.07	.25	n.a.	11 x 17 [d]
34 x 44	.50	.20	.12	.46	n.a.	17 x 22 [d]
27 x 49	.55	.20	.12	.46	n.a.	18 x 24 [d]

[a] Cut-sheet size; actual copy may be slightly smaller. [b] Reproduction not quite full size; reduced 16X and enlarged 15X
[c] Reduced 24X and enlarged 15X. [d] Reduced 30X and enlarged 15X. n.a.—Information not available.

tionary, and continuous flow. In continuous-flow cameras, such as the one at Murray Hill, the document is photographed as it moves through the machine. The camera is normally compact and moveable; can be operated in a fully lighted room. Such cameras are photoelectrically triggered by leading and trailing ends of drawing but are automatically programmed to give 2-in. film advance regardless of drawing length.

Flat-bed cameras are being successfully used in other microfilm installations and have the inherent advantages associated with stationary photography.

Some companies may wish to have microfilming done by specialists. The National Microfilm Association can recommend qualified service companies. They are familiar with pecularities and special conditions associated with the microfilming of engineering drawings, as contrasted with microfilming of other office documents.

Film processor

Exposed film can best be processed by a commercial film service, but if this results in a delay of more than two days, an office-type processor should be considered. Ours at Murray Hill can turn out a 100-ft roll of standard microfilm in an hour. And with so-called "prehardened" film, time can be cut to a half hour.

The advantage of having a processor on location is, of course, to speed time between issuance of a drawing and the arrival of the film card microcopy in the file. Equally important: Camera failure or operator error can be quickly picked up.

Test and inspection instruments

Resolution and background density are the two characteristics of microfilm that can, and must, be checked to standards. A good-quality microscope, 30 to 50 power, tests resolution of microfilm and a densitometer checks background density. Suitable light box, rewind gear, splicer and a good microfilm reader, preferably motorized, complete the test and inspection instruments.

Electric accounting machines

Those companies that handle payrolls on punched cards already have necessary EAM equipment—card punch, verifier, interpreter and reproducer. In metropolitan areas, there are commercial tab card services that will punch cards from information on the film.

Film mounter

Hand-operated mounting machines have a die which cuts film and presses the edges against pressure-sensitive tape surrounding the card aperture. Though the operation is not difficult, some care is needed when centering the image and in prewinding roll film to minimize curl. Semiautomatic mounters are available which incorporate a reader. This allows checking the film against corresponding aperture card.

Storage cabinets

Film cards can be stored in: (a) standard cabinet with 10 drawers, more or less (two card trays per drawer), (b) tub files with open trays, and (c) rotary files, manual or motorized. The tub files give best access where several clerks are working the file at the same time; rotary files permit fastest selection, assuming drawing numbers are largely sequential and there is one clerk at the file. Upright cabinets, the best space saver, hold 60,000 to 65,000 film cards; tub files, occupying the space of an office desk, 15,000 to 20,000. Most important criteria

Continuous-flow camera . . . copies drawing on 35mm film as it passes through this machine. Operator is checking background characteristics of drawing with built-in lightmeter.

when choosing storage cabinets are: How large is the file? How much space is available? How active is the file? How many clerks will want access simultaneously?

Film-duplicating machines

Duplicate film cards are commonly made by placing the master card in contact with a second card which has raw diazo or Kalvar film mounted in the aperture. Both cards are put in a small machine and film is exposed by ultraviolet light. Diazo film is developed in an ammonia vapor chamber; Kalvar film is developed by application of heat. Time for making a duplicate by either process runs from 30 to 75 seconds. Diazo gives a negative duplicate from a negative original–an identical copy. Kalvar, a reversal process, gives a positive duplicate from a negative original. This equipment is still subject to some development and improvement.

Microfilm readers

Ideally, the reader should project an image, as large as the original drawing, and sufficiently intense and clear to be read easily under normal room light. But because of variety of reduction ratios used when microfilming, full-size images are not always possible. However, half-size images are acceptable for most purposes.

Two types of such readers are available for card-mounted film. One projects enlarged images on the front of an opaque screen; the other projects them on the back of a translucent screen. Hand viewers, which simply magnify the film, are portable and convenient but magnification is relatively low and field of view is limited.

Projection readers are available in a number of different screen sizes. A reader with 18 x 24-in. screen has a magnification of 15 dia and will enlarge largest drawings (34 x 44 in.) to half the original size. Smaller drawings can be viewed on readers with 12 x 18-in. screen. Smaller readers are useful but cannot view entire frame at once.

Enlarger-printers

What about those times when prints are needed? They can be made by three processes: (a) projection on photographic paper with a "stabilized" photographic development, (b) projection on special diazo-coated papers with the usual diazo development, and (c) electrostatic projection and development.

The first type turns out satisfactory prints but is comparatively expensive to operate. Diazo-type holds promise but is considered limited to smaller size prints.

Electrostatic enlarger-printers give good-quality prints at a cost competitive with blueprints. This process has the advantage of being completely dry. At least one high-capacity (20 ft/min.) unit is presently available but limited to large-volume work that justifies the very high initial investment.

REPRINT of this article can be obtained for your reference file by checking **E46** on one of the Reader Service cards bound in this issue. For further reprints available see "Current Reprints" listing in this issue on page 115.

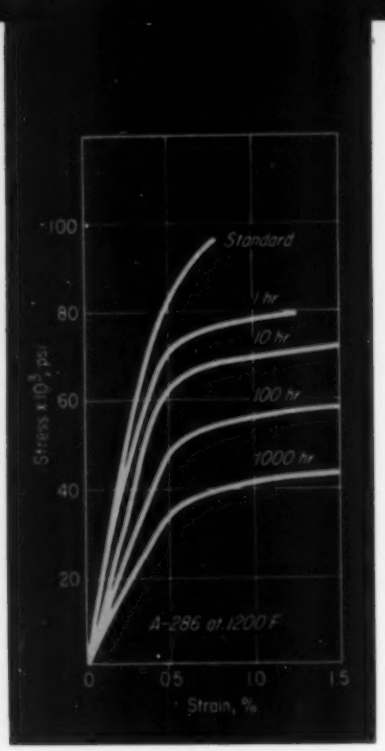
EDITORS NOTE: For more about engineering drawings on microfilm—equipment, systems and supplies—use the following list of manufacturers and suppliers in the field. They should be consulted before beginning any microfilm program—whether 35mm, 70mm, or 105mm.

*Ozalid Div of General Aniline and Film Corp
*Recordak Corp
*Microdealers Inc (a group of independent, commercial microfilmers)
Photostat Corp
Keuffel & Esser Co
Charles Bruning Co Inc
Flofilm Div of Diebold Inc
The Haloid Co
Remington Rand Div of Sperry Rand Corp
Technifax Corp
Kalvar Corp

*These companies distribute (in addition to their own microfilm equipment) Filmsort aperture cards, and Filmsort machinery for mounting, viewing and reproducing 35mm film. These cards, heart of the system described in Mr. Locke's article, are a patented property of Filmsort Div of Miehle-Goss-Dexter Inc, Pearl River, NY.

For more about microfilm; who's using it and what's to be gained, see "For Today's Draftsman—These Modern Tools," Oct 13 '58, p 68. Installation of microfilm equipment at Air Force's Wright Air Development Center is described in, "Armed Forces to Mechanize Storage of Drawings," Mar 17 '58, p 19.

For a rundown on reproducing methods and equipment, other than microfilm, see "Choosing Equipment for Drawing Reproduction," Jan '57, p 135. And for a comparison of cost, space utilization, and accessibility of full-size drawings stored in rolls, in vertical files, and in horizontal files, see "Filing Equipment for Engineering Drawings," Mid-Oct '57, p A8.



Family of curves . . .
shows how slowing the strain rate lowers both tensile strength and elastic modulus.

Working with metal often involves mechanical properties that seem hidden—but can be found right in the test data. That's why, to get around design troubles, take these . . .

7 closer looks at METAL PROPERTIES

EDWARD LORIA, Staff Metallurgist, Crucible Steel Co of America

The tear test was dreamed up by aircraft and missile designers—they had to know how fast the damage spreads when a metal starts ripping. Until recently, such properties were known only to specialists. Today, they can be judged by the workaday testing lab. But they are commonly overlooked. And so are other properties that only require digging deeper into such test data as those for creep, stress rupture, fatigue and notch-tensile strength.

Formerly, ignoring these properties might not have mattered much. Today, design is being pushed by competition toward better price and performance, lower weight and size. It is no longer good enough to evaluate a product in terms of such old standbys as ultimate tensile and tensile yield strengths. How, specifically, will a metal react in a certain environment? Answers given by the much-publicized environmental testing methods are insufficient. They tell, only after a part is made, how it will act.

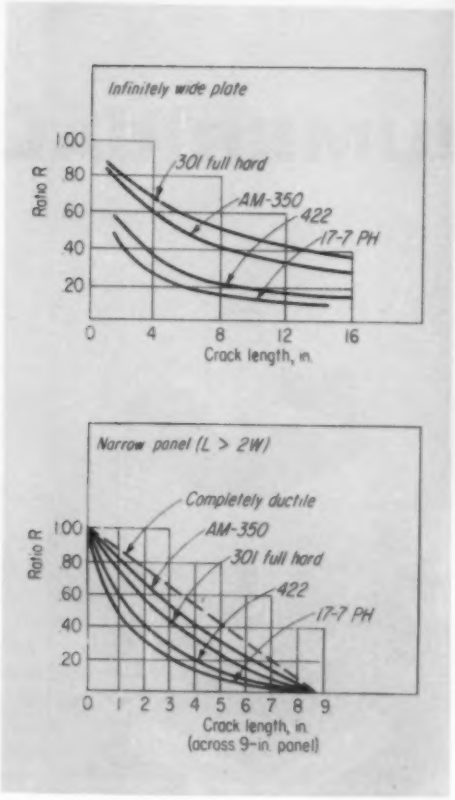
Here are seven of the finer points to watch for when examining test data. They will tell you more about how close you can push steels, and sometimes other metals, to their limits.

1 Strain rate . . . is how fast an applied load stretches the material. A ductile part under load usually strains, and thereby relieves its stresses. But when stresses remain or are aggravated by the strain, they can affect strength in one of two ways. Slow strain rates, as in creep, lower both yield and ultimate strength. Rapid strain can raise these strengths, widening the range between them and increasing the apparent ductility. Forming with explosives *(PE—Jan 6 '58, p 56)* takes advantages of this to successfully work metal otherwise too brittle for normal forming processes. A good rule is: Before using yield-strength data, check the strain rate. If it is not given, or is in the wrong order of magnitude, further testing may give more reliable design data.

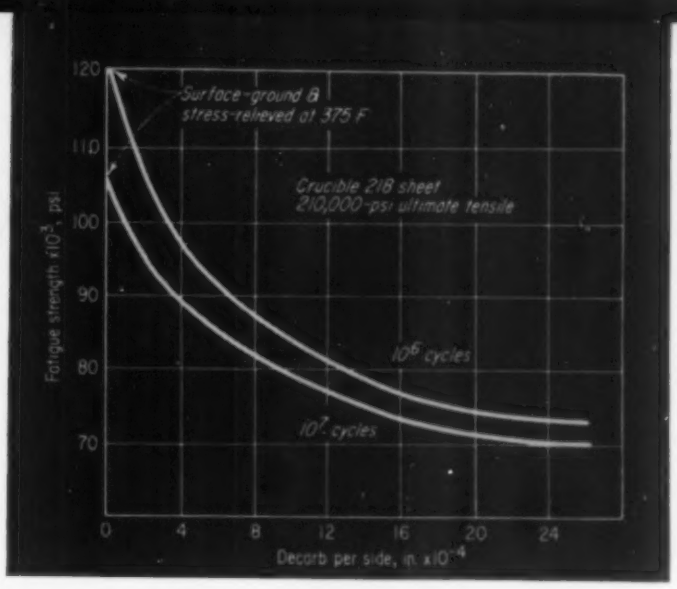
2 Transverse properties . . . of forged metals, especially steel, should be compared after final heat treatment. In general, the steels that need quenching and tempering for strength lose some directional properties and have higher transverse ductility than the semi-austenitic steels —which gain strength from precipitation hardening. Also, the test data is meaningless unless materials are compared with equivalent forged reductions. Sometimes a steel chosen for other properties lacks sufficient transverse ductility: One possible remedy is vacuum melting—it improves this ductility, especially at the very high tensile levels.

3 Compressive strength . . . normally approximates tensile strength but should not be taken for granted. Theoretically, direct compression should not cause failure because the stresses are spread over the larger area caused by deformation. But practically, most compression failures come from buckling of sheet fabrications designed for high moment of inertia. Working metals into sheet raises tensile strength but does not give the same rise in compression *(PE—Dec 9 '57, p 72)*. And compression properties in transverse directions differ too. So for best design, thin sheet materials must be fabricated with a specified rolling direction. When practical, stress the sheet in tension and specify cast materials for compression loads.

4 Fatigue strength . . . shows smaller gains when steels are alloyed to improve rupture and creep strength. Generally, design has to meet rupture and creep limitations at high temperatures and yield or fatigue limits at



Tear resistance . . .
differs in wide and narrow panels. Here, *R* is ratio, after crack occurs, of actual tensile strength to tensile strength calculated for the same area.



Decarburization . . .
lowers fatigue strength in axial-tension tests.

lower ones. But if stresses reoccur often– if 10^7 cycles are completed in less than 1000 hr–the lowered fatigue strength becomes the deciding factor at higher temperatures.

In mechanical fatigue, a material satisfactory at room temperature should remain so at high temperature because fatigue strength drops slower than tensile strength. However, where short life permits high design stresses above the yield point, the fatigue data is inconsistent and spreads properties as much as 200 to 300%. The same is true when the high stresses are caused by restricted thermal expansion. The endurance-limit curve should therefore only be a guide and environmental testing is needed.

5 Tear strength . . . predicts how fast a crack spreads once it has started. A high ductility or low ratio of yield to ultimate strength gives high resistance to tear. But steels also differ according to proportion of length to width. When tear data are not available, choose material with a ratio, yield to ultimate strength, below 0.85–the inherent ductility will minimize notch sensitivity.

6 Bi-axial stresses . . . like those in internal combustion cylinders can be simulated by testing cylinders hydraulically. These tests show that uni-axial tests cannot predict bi-axial performance. The brittleness of many steels hardened to above 200,000-psi ultimate makes them fail below their uni-axial yield strength. In bi-axial tension, the elastic modulus varies with load (*PE—Jan 6 '58, p 68*) and a steel will take higher stress before showing deformation or strain. Therefore a part needs more ductility when stresses act in more than one direction. The same steel at lower strength, but with more ductility, will often do the job better.

7 Surface defects . . . such as decarburization from hot-rolling and heat treatment must be avoided because they lower tensile strength in thin (below 0.020 in.) sheet. At 0.040 in. or above, the tensile strength holds up but fatigue strength can go down as much as 40%, especially in hot-work die steels for ultrahigh-strength jobs. It's different with austenitic stainless steels, which do not decarburize in oxidizing atmospheres; they, however, lose both corrosion resistance and ductility by absorbing carbon from reducing atmospheres. Hence the need to recognize the type of steel and, in an assembly, use similar steels so the same heat treatment will serve for all. This will lower cost and reduce chances of shop errors as well as avoid mismatched thermal expansion that builds up stresses.

Contrary to common belief, removing surface defects in sheet metal by grinding does not lower fatigue strength. The many fine scratches distribute the stress concentration from each individual notch.

EDITOR'S NOTE: For more on mechanical tests and how to get most out of them, see:

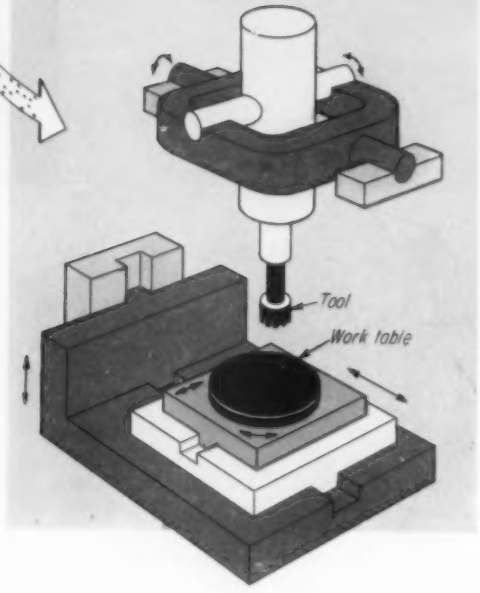
"How to Calculate Stress in Short Cylindrical Shells," Feb 3 '58, p 81—formulas for deflection, shear forces and bending moment caused by external forces such as flange expansion and centrifugal forces.

"High-temperature Stainless," Apr '57, p 135—eight stainless steels for temperatures from 600 to 1400 F.

"How to Measure Principal Stresses," Oct 14 '57, p 101—distribution patterns for normal stresses and methods that use one strain gage to find principal bi-axial stresses.

"Rapid Weight-strength Analysis of Pressure Vessels," Oct 14 '57, p 95—simple weight-volume formulas for cylinders, spheres and elliptical heads. Included are recommended proof-pressure stresses for 8 common materials.

NUMERICAL



Six directions of motion . . .
are practical limits of this hypothetical machine tool's versatility. If speed, position and sequencing of each movement are controlled, at least 6 times 3, or 18, separate control signals are needed—a job for numerical control.

Goodby to need for templets—or manual skill—
when design exploits the advantages of punched tape and coded cards.
Here are the ABC's of this modern concept in the art of removing metal.
How the engineering drawings should be made to increase benefits
of this control method was discussed in last week's issue.

MURRAY ROSENBLATT, Specialty Control Dept, JOHN L. DUTCHER, Equipment Industries Engineering, General Electric Company

A new kind of boss–numerical control–is now telling automatic machine tools what to do. It eliminates much of the need for human skill, and also does away with templets, complex jigs and fixtures.

Its instructions are given by coded numbers in the same way that information is fed to a digital computer. Each order to the machine, such as telling which slide to move, and how fast, needs a separate instruction. Combined, they add up to the machining of complex parts.

The instructions can be represented by holes punched in tape or cards, by magnetized areas on magnetic tape, or by numbered positions on dials. The choice depends upon the application.

Suppose you have to drill a number of accurately located holes in a small part. The workpiece is clamped on the table, the control is zeroed with respect to location of the part, and the proper tools are inserted. Instructions on the punched tape (or cards) might read:

Position 1 (first block of information): "Move table to position 4.500 in. in longitudinal direction . . . move table to position 3.255 in. in transverse direction . . . turn tool turret to position #4 . . . start spindle to rotate tool at 600 rpm . . . turn on coolant." This has, in effect, moved the workpiece so that the first hole is positioned to the required accuracy for drilling (±0.001 in. is common). All these orders were fed as a group to control equipment able to interpret them. The instruction might actually appear on the tape as "A4500 B3255C4D6EM."

Position 2: "Feed drill down to 0.520 in. at 5 in./min. and retract." The hole is now drilled to correct depth.

Position 3: This instruction would be much like that for Position 1 except that it would designate a new hole location and possibly a new tool speed and tool-turret position. A series of holes are accurately drilled in a minimum of time, with the simplest of work-holding fixtures and without an expensive drill jig.

CONTROL

That example is numerical control of the discrete-positioning type. It simply positions the tool or work from point to point.

Numerical contouring (continuous-path control) is more complex–but permits moving three or more slides simultaneously at different and smoothly varying rates to perform 3-dimensional machining. Information is still fed into the system in groups or "blocks" but the control is able to store and convert it so the tool path can be continuously controlled.

Incorporated in any of these systems is some form of position-sensing or measuring device. It indicates status of the machining operation and provides position feedback to the control.

DISCRETE POSITIONING FOR SIMPLICITY

The simplest systems are of the discrete-positioning type. They instruct a tool or table to move from one point to another and then perform an operation like drilling, punching or welding.

WHEN THEY SAID NO TO ELECTRONICS

Three years ago (*PE—Sept* '55, *p* 162) machine-tool users were asked what they needed or disliked in controls. At that time, electronics was not in favor. Typical comments were: "Tube life is inadequate"; "Unnecessary refinements result in complexity"; "Extraordinary maintenance of circuits required." Tape control seemed remote.

Today the trend is definitely electronic–note the switch to punched cards and tape by industrial and aircraft metalworking plants. The change has come partly from reliable, smaller and less costly vacuum, magnetic and solid-state control elements, partly from intensive development of computers and machine-tool controls.

Numerical control makes the basic machine smarter, and is competitive not only for fairly high production, but also for small-lot machining of special parts.

A discrete control can also govern tool speeds, sequencing, timing, tool selection and other auxiliary operations. It may arrange for final tool positioning from the same direction each time to eliminate errors due to backlash in the machine drive–the same procedure that would be directed manually by an experienced machine operator.

Such controls also permit continuous machining between discrete points if the path is in line with a machine axis so that only one feed should move (with the others holding accurate fixed positions). Or they can permit machining at an angle if lesser accuracy will do.

Input instructions are usually given by punched tape or cards, but other numerical input methods, including groups of manual switches or dials, are common.

Manual numerical input, the least expensive, is considerably slower and less dependable than with cards or tape, but faster and more accurate than with non-numerical manual operation. In conjunction with cards or tape, it often solves special problems by permitting the operator to introduce instructions directly.

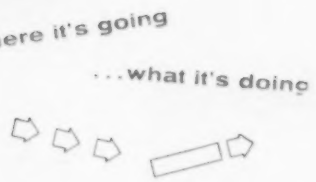
Punched tape input can be provided by office-type tape punches and readers. For checking, the tape is usually run through the reader and a copy is typed out automatically. Or the holes can be checked visually. Ends of the tape may be glued together in a closed loop, eliminating rethreading when duplicate parts are to be produced. Editing is simple–the tape can be spliced; operations can be omitted by punching "delete" holes.

Punched cards cost more to handle than tape because the reading and punching equipment is more complex. Also, stacks of cards are not as convenient as a continuous loop of tape. However, changing and editing are easy–simply remove or replace individual cards.

Magnetic tape can present data in an extremely concentrated form. It has not yet been used with discrete-positioning systems because of the cost of the reading and recording equipment. It may have applications in the future for unusually large quantities of input data.

CONTINUOUS-PATH CONTROL FOR CONTOURS

Numerical contouring is more complex and costly (about $35,000 to $65,000 vs $10,000) than the discrete systems, but does different and harder work–the type



previously handled by templet tracers. It substitutes numerical data on tape for the templet or model.

This continuous-path control is not as common as the discrete method, because possible uses are far less varied and numerous, and first cost is higher. Also, preparation of input information on magnetic or punched tape is far more complex, generally requiring computers and other data-processing equipment. However, contouring is becoming accepted because of its manufacturing economies and greater machining accuracy. At least 50 such machines are now operating and over 50 more are being built. The majority are for the aircraft industry but the list of non-aircraft applications is growing.

A forerunner of these tape controls was developed over 10 years ago. Movements of the machine tool are recorded on magnetic tape while the machine is producing a sample part. Then, for succeeding parts, the tape is played back. Nonproductive portions of the cycle are not recorded, therefore not repeated when succeeding parts are made. The method showed a machine could be controlled accurately by tape.

Numerical contouring goes even farther: Its control tape is prepared from numerical data—without first making a sample part.

FROM DRAWING TO TAPE

The possibilities of numerical control should be considered early in a design because both the shape of the product and the way this shape is defined on the drawings will affect the economics of production.

First step in numerical contouring is programming—interpreting the prescribed lines and curves so they can be expressed in numerical form. A digital computer is then normally put to work reducing this data to the specific form required to describe the necessary tool path.

While the data actually fed to the machine tool may be of continuous or incremental nature, all dimensions in the original engineering drawings must be referred to a single reference point. For example, if the part has two parallel surfaces, the drawing should specify the location of each surface with respect to some zero-zero axis rather than specifying the location of one surface and the distance between it and the second.

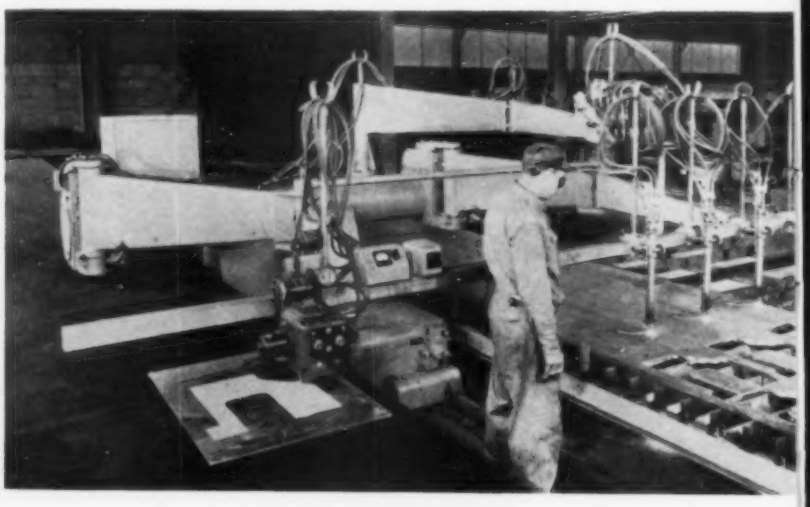
Try to use lines or surfaces that are easily defined in mathematical terms, such as straight lines, segments of circles, and parabolas. Empirical surfaces produced by a modelmaker or drawn from a French curve give more difficulty. But any surface can be handled.

The programmer, who determines how the part will be machined, must be competent and very careful, because the cutting tool will follow his instructions even if he is obviously wrong. He must know capabilities of the machine tool and tooling—depth of cut, and feed speeds that will not give excessive deflection or vibration.

The control system can compensate for some machine deficiencies such as a slight backlash and windup, providing the feedback instrumentation is installed close to the cutting tool. But for satisfactory results the machine must be of good design, well built, and in excellent mechanical condition.

FROM TAPE TO TOOL

Position-sensing devices connected to each machine slide provide signals (usually electric) that indicate machine position. Electric signals of the same form come from the tape or cards. The control compares these



Photoelectric line-follower . . . is not numerically controlled, but tracer head at left, sensitive to light-and-dark, follows outline of pattern. Flame cutters at right can duplicate pattern within 0.01 in. at speeds up to 20 in./min.

TEMPLET CONTROLS—Automatic, Not Numerical

Templet tracers–which cause a machine to duplicate the shape of a templet or model–are automatic to a degree but the majority of decisions are left to the human operator. Tracer-controlled machines, the answer to contour-machining problems for years, have only recently begun giving way to numerical control.

The most common tracer systems are simple "position" regulators. The stylus of the tracer head is moved along in contact with the templet by an independent feed. Any change in slope deflects the stylus and causes the tracer head and tool move in or out at the speed required to keep the stylus in contact.

Hydraulic tracer head . . . contains a valve actuated by deflection of the stylus. It ports oil directly to the hydraulic motor or cylinder that moves the tracer head and cutting tool.

Electronic tracer head . . . depends on electrical unbalance to sense a change in stylus deflection. Electrical output of the head is amplified to control an electric motor or electro-hydraulic servo.

The more complex tracer systems can control two or three machine feeds simultaneously to do profile milling or turning, or 3-dimensional work such as die-sinking.

Tracer controls have certain disadvantages. Setting up templets on the machine is time-consuming and rather delicate. The machine must be larger to provide space for mounting the templets and tracer head–and these must be close to the cutting tool, yet accessible for adjustment and changing. Rigidity is a critical requirement because any relative variation between tracer and tool positions will cause errors.

But tracer controls will never be fully replaced by the numerical method . . . they cost less ($2,000 to $20,000 is typical range), and many jobs don't require the higher accuracy of numerical control.

Line Followers

A variation on templet tracers is an electronic sensing-head and control that follows a line drawn on metal, tracing cloth, or paper. One type depends on electrical conductivity of a silver-ink line to guide the tracer. Others feature photoelectric heads that sense reflection from a beam of light focused on (or sweeping across) the line.

Line followers have found widest application on gas-torch flame-cutting machines that cut parts from steel plates, but these have relatively low accuracy. A few higher accuracy, line-following systems mill templets directly from line drawings. Limitations are: Difficulty in drawing accurate lines for them to follow, need for a high degree of cleanliness at the machine, and fairly high cost of control.

position and input signals, then orders power servos to move machine as required for matching the signals.

Vacuum tubes, transistors, or both, are needed for such control equipment. Today's position-sensing (feedback) devices include synchros or other such inductive devices and electromagnetic or photoelectric pulse generators. Synchros give a continuous electrical indication of machine position; the others provide an electrical pulse each time the machine has moved a specific small distance.

Power elements, the servos, may be either all-electric, using dc motors and generators; or electro-hydraulic, with electrically operated hydraulic valves and hydraulic motors or pistons. All-electric drives are usually more reliable and more tolerant of some machine deficiencies. Electro-hydraulic drives are more compact, can have faster response, but require better-designed machines. Either type is adequate for almost any application; the choice is usually governed by secondary factors such as convenience.

REPRINT of this article can be obtained for your reference file by checking No. E45 on one of the Reader Service cards bound in this issue. For other reprints available see "Current Reprints" listing in this issue on page 115.

EDITOR'S NOTE: How the engineer, in his designs and drawings, can better communicate with these new machines, is discussed in "Numerical Control and the Design Engineer," Oct 20 '58, p 23.

A previous article, "Fluid Power for Machine-tool Controls," Aug 18, '58, p 70, examines this revolution in automatic machines from a different viewpoint—that of hydraulic- and pneumatic-component manufacturers.

Trends in automatic machines have been reported in these articles and case histories:

"What User Wants in the Design of Machine-tool Controls and Drives," Sept '55, p 162, is an industry-wide survey quoting frank opinions about desirable and undesirable features in both manual and automatic equipment; "Numerically-controlled Jig Borer, Feb '57, p 148, shows how punched tape can control machining with digital-to-analog converters and electrical position-sensing heads; "Tape-controlled Machining in Small Lots," Jan '57, p 209, demonstrates that single-part production using lathes, boring mills and contouring mills can be made automatic with templets and punched tape; "Electronic Tracing Systems Control Milling Machines," July '57, p 150, features two machines that trace templets electronically, with feedback control; "Automatically Positioned Turret Punch Press," Sept '55, p 144, describes a punched-card-operated machine that triples output; "Spark-gap Tracer Control," Sept '55, p 148, shows how milling machines can trace directly from a conductive silver-ink drawing, eliminating need for templets or punched cards.

Control and feedback devices are described in "Rotating Components for Automatic Control," Nov '53, pp 129 to 160, a special report on potentiometers, function generators, servomotors, synchros, tachometers, transformers, and special motors.

Special reports have reviewed current trends in the machine-tool industry: "Bellwether With Wings," July 7 '58, p 52, shows the strong influence exerted by the aircraft industry; "Design for Automatic Production," June 23 '58, p 82, demonstrates how design of both the product and the machine tool to build it must be considered concurrently; and the issue of Aug 4 '58, p 21, tells how aircraft contractors must automate to stay competitive.

ROBERTS' LAW HELPS YOU FIND...

alternate four-bar linkages

For every linkage there are two substitutes that will produce the same desired motion—so says a little-known law that can be applied graphically to give quick results. Author furnishes three examples, including his own method of applying the law.

R T HINKLE, Professor of Mechanical Engineering
Michigan State University

Quite often, when a four-bar linkage has been designed or selected from a catalog to produce a desired coupler curve, it is found that one of the pivot points is inconveniently located or that the transmission angles are not suitable. (A coupler curve is produced by a point on the connecting rod joining the two cranks of the four-bar linkage). According to Roberts' Law there are at least two other four-bar linkages that will generate the same coupler curve. One of these linkages may be more suitable for the application.

Roberts' Law is not widely known and does not seem to be mentioned in any English-language textbook. The law states that the two alternate linkages are related to the first by a series of similar triangles. This leads to graphical solutions of which three examples are shown below—the first involving similar triangles, the second being a more convenient method developed by the author, and the third illustrating solution of a special case where the coupler point lies along the connecting rod.

Method of Similar Triangles

Four-bar linkage *ABCD* in Fig. 1 uses point *P*, which is actually an extension of the connecting rod *BC*, to produce desired curve. Point *E* is found by constructing *EP* parallel to *AB*, and *EA* parallel to *PB*. Then triangle *EFP* is constructed similar to triangle *BPC*. This involves laying out angle α and β.

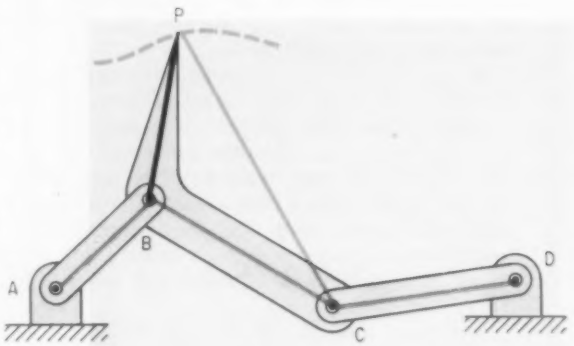
Point *H* is found similarly and point G is located by drawing *GH* parallel to *FP* and *GF* parallel to *HP*.

The two alternate linkages to *ABCD* are *GFEA* and *GHID*. All use point *P*, to produce the desired curve; and given any one of the three, the other two can be determined.

The Author's Method

With the similar-triangle method described above, slight errors in constructing the proper angles lead to large errors in link dimensions. The construction of angles can be avoided by laying off the link lengths along a straight line.

Thus, linkage *ABCD* in Fig. 2 is laid off as a straight line from A to *D* in Fig. 3. Included in the transfer is point *P*. Points *EFGHI* are quickly found by either extending the original lines or constructing parallel lines. Fig. 3, which now has all the correct dimensions of all the links, is placed under a sheet of tracing paper and, with the aid of a compass, links *AB* and *CD* are rotated (see Fig. 4) so that linkage *ABCD* is identical with that in Fig. 2. Links *PEF* and *PHI* are rotated parallel to *AB* and *CD*, respectively. Completion of the parallelogram gives the two alternate linkages *AEFG* and *GHID*.

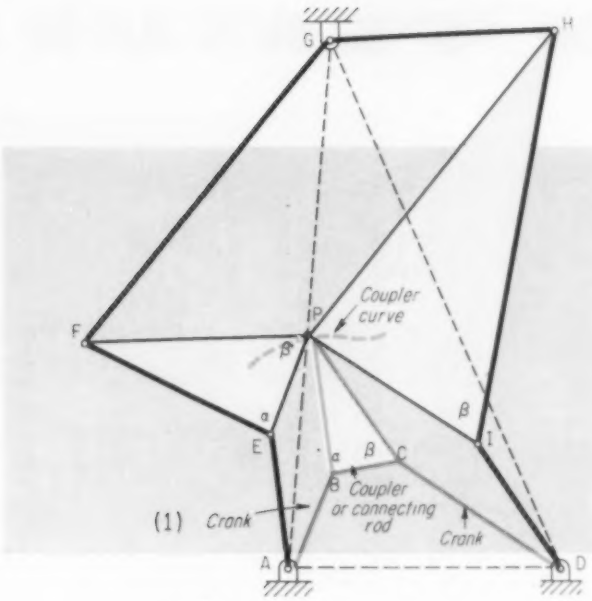


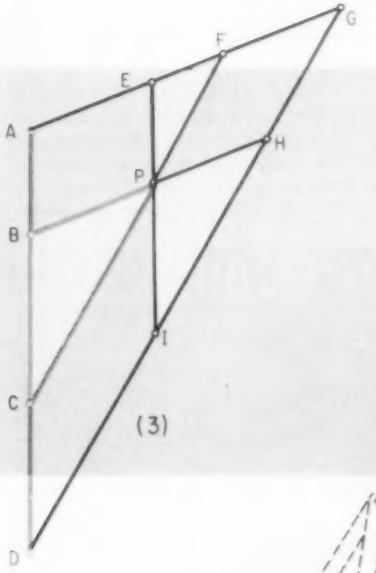
(2)

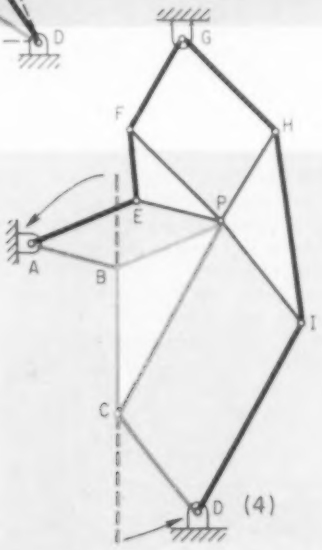
Special Case

It is not uncommon for the coupler point *P* to lie on a line through *BC*, Fig. 5. Links *EA*, *EP* and *ID* are quickly found by constructing the appropriate parallel lines. Point *G* is located by using the proportion: *CB*:*BP* = *DA*:*AG*. Points *H* and *F* are then located by drawing lines parallel to *AB* and *CD*.

THE 3 LINKAGE EXAMPLES







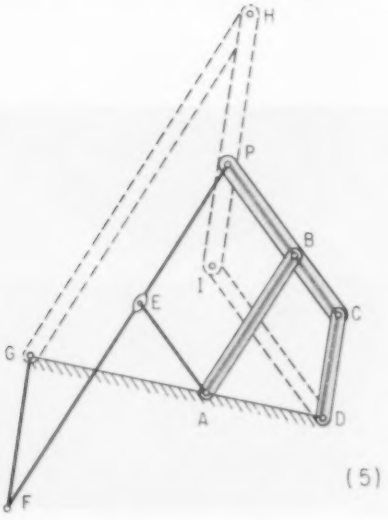


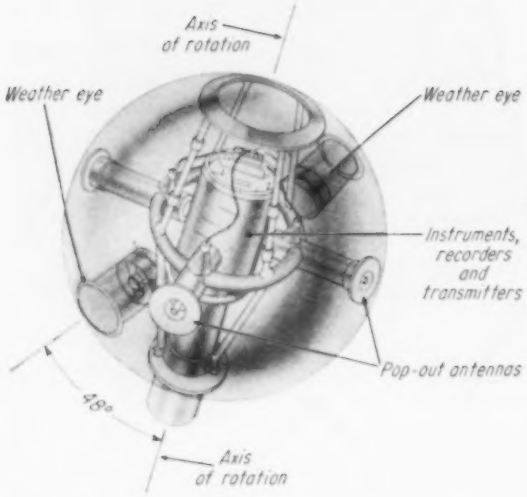
Fig. 1—Method of similar triangles

Figs. 2, 3, 4—Author's method, step by step

Fig. 5—Special case shows simplicity of applying Robert's Law

EDITOR'S NOTE: Germany is now swinging over toward four-bar linkages—in preference to cams—for translating motion in high-speed machines and computers. For details, see "Linkages Gain on Cams," Dec 23 '57, p 75.

How Coriolis acceleration effects rotating components such as linkages is discussed in "Coriolis Acceleration—a Force to Be Reckoned With," May 26 '58, p 73.



This WEATHER REPORTER goes into ORBIT

An important mission for the Vanguard rocket is to put a pair of satellite-riding "weather eyes" into orbit. By measuring light bounced off clouds, the 2-eyed device will give earthlings a panorama of the coming weather.

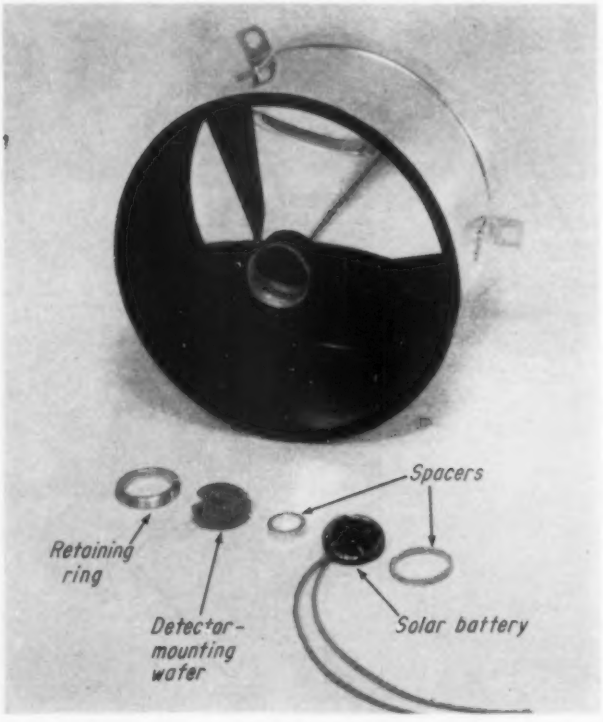
Looking down from beyond the earth's atmosphere has long appealed to meteorologists—and this, the eyes will do. One can look forward and the other backward from 20-in. spherical satellite on whose core they are mounted. Built by Perkin-Elmer Corp, Norwalk, Conn., and designed by US Army Signal Research and Development Laboratories, Fort Monmouth, NJ.

Riding a satellite . . .
the "weather eyes" will reveal cloud formations by measuring light reflected back up from them—and thereby help forecast the more violent weather phenomena.

At an altitude above 200 miles the eyes will sweep a path 600 miles wide. The wide area is possible because a short-focal-length (f/0.7) parabolic mirror focuses light onto a detector 1 mm square.

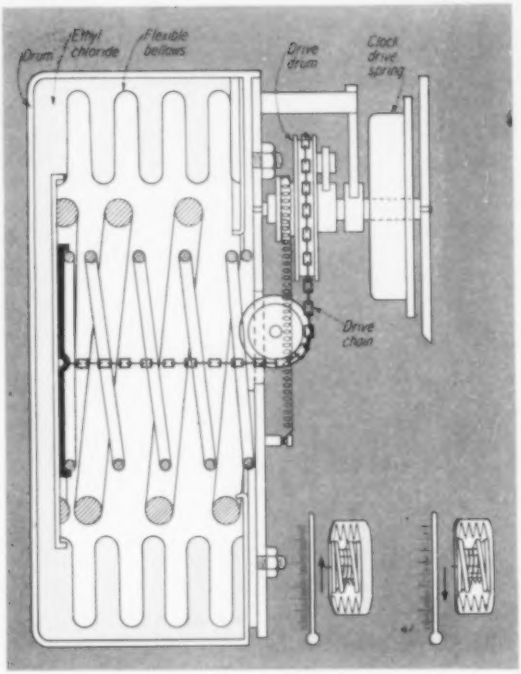
Line of sight is at 48° to spin axis of the satellite's rotation. The "eyes" each have one detector and are mounted back to back. One eye sweeps down and forward, the other sweeps down and aft.

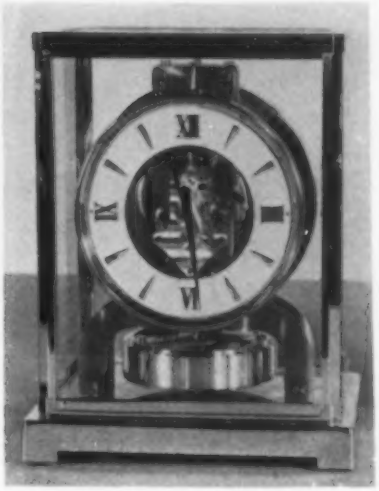
Information is stored on tape and, on electronic command, telemetered to earth. Oscillographic playback devices make allowance for changes in satellite orientation. The sweep will continue as long as the satellite is within 1700 miles of the earth.



Each goldplated eye . . .
with detector and solar battery weighs 3½ oz, and is made of 0.010-in., Type 430 stainless butt-welded into cylinders. Additional stiffness is provided by the bead spun on front edge of the cell. The 430 stainless and BSC-2 primary mirror glass for optical system were selected as the best possible match of thermal expansion.

The primary mirror is bonded in place and permanently focused on the detector cell. Supporting ribs are spot-welded to the main cell and silver-soldered to the brass detector cell. Detector, and solar battery that turns detector on and off, are held in detector cell by threaded retaining ring, and positioned by insulating spacers.





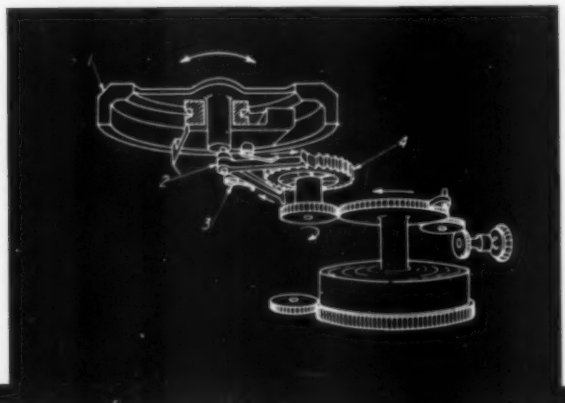
Rising temperature . . .
expands ethyl chloride gas contained in space between flexible bellows and metal drum. Gas compresses the bellows and springs, and drive chain is wound on spring-loaded drive drum. Dropping temperature lowers gas pressure; springs expand the bellows, pulling chain to wind clock drive-spring.

Clocks now wound by HEAT

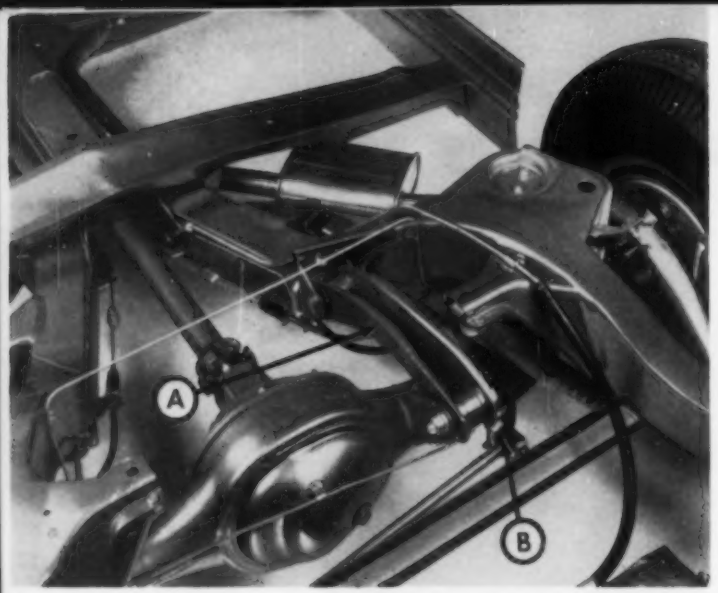
Gas responds to temperature variations and winds new Swiss timepiece pictured above. Like two random-motion methods also shown on this page (at right and below), it suggests ways to simplify operation and maintenance of unattended equipment.

The self-winding timepiece movements show what the Swiss are doing in this field with unconventional energy-storing methods. Clock is by Le Coultre Watches, Le Sentier, Switzerland.

Gearwheel rocker . . .
Alternating movement of swing mass (1) is "rectified" by a gearwheel rocker (2) and transmitted to the drive gear (3). Gearwheel rocker shaft is free to rotate, bringing either gearwheel into mesh according to the direction of rotation of the swing mass. Reduction gearing is used to wind spring.



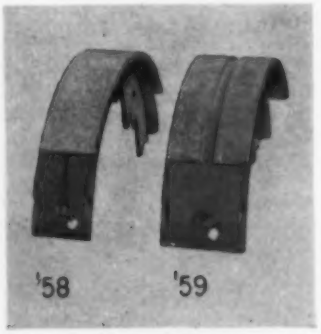
Eccentric drive . . .
Shaft of the free rotor (1) carries two eccentrically mounted actuating pawls (2). Springs (3) keep the pawls and pawl wheel (4) meshed. Pawl wheel is driven in one direction to wind spring, regardless of direction the rotor rotates. Large mechanical advantage of eccentric drive simplifies reduction gearing that winds the mainspring. Knob can be used for manual winding.

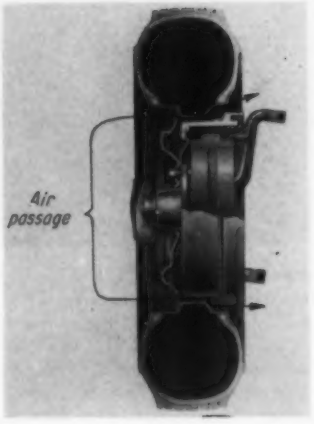


Rear-end refinements . . .
include the addition of two suspension components. The '58 integrated control arms have been replaced by an over-mounted torque rod *A* and track bar *B*. The pivoted torque rod prevents axle windup and rear-end squat during acceleration. Side sway will now be controlled by the track bar. Adding these components further indicates trend to provide the improved chassis and suspensions necessary to keep up with increased horsepower in today's automobiles.

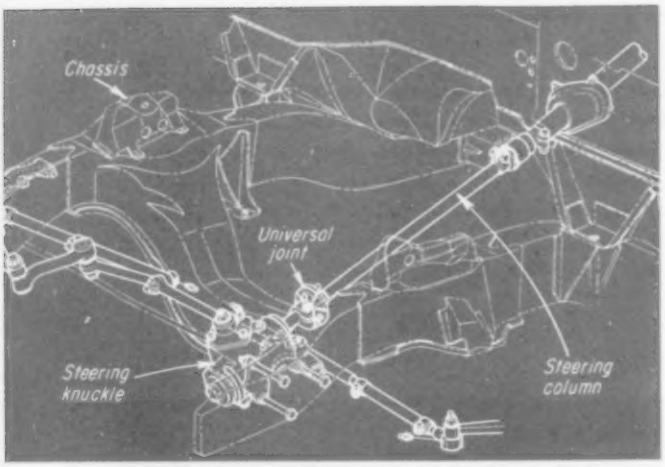
Let's See What's New with Chevy

It's under its '59 dress that Chevrolet has made some engineering changes worth noting. As with other cars, these modifications provide better brakes and better handling—reflecting the influence of sports-car thinking on Detroit engineering.



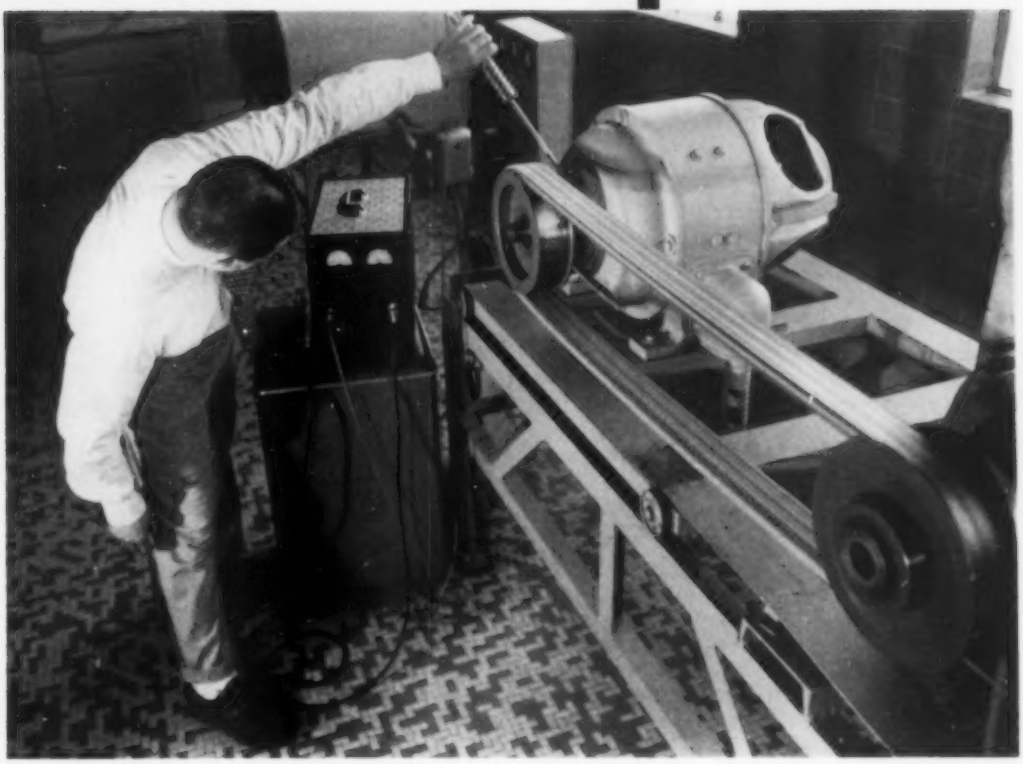


The brakes . . .
have received more attention in the '59 cars than any other mechanical component. Chevy has increased its brake area 27%, front brake shoes are wider by ¾ in., and rear brake shoes by ¼ in. Added width of brake drum projects into the air stream to aid cooling. Openings in wheel flange improve air circulation around brake drum (arrows) and speed heat dissipation.



Highway vibration . . .
is absorbed by new universal joint in the steering column. Located directly above the steering knuckle, the yoke-and-trunnion-type joint uses a rubber-impregnated, molded-cloth trunnion. Also, raising the steering ratio to 28:1 improves the mechanical advantage, eases parking and steering at low speeds.

Amplitude of vibration . . .
measured on the motor end bell in a plane perpendicular to motor shaft is 0.0003 in.; an endless solid belt (corrugated on inside face) shows amplitude 4 to 11 times greater. Test shown here was run at 1750 rpm, belt speed 4720 fpm, transmitting 3.24 hp.



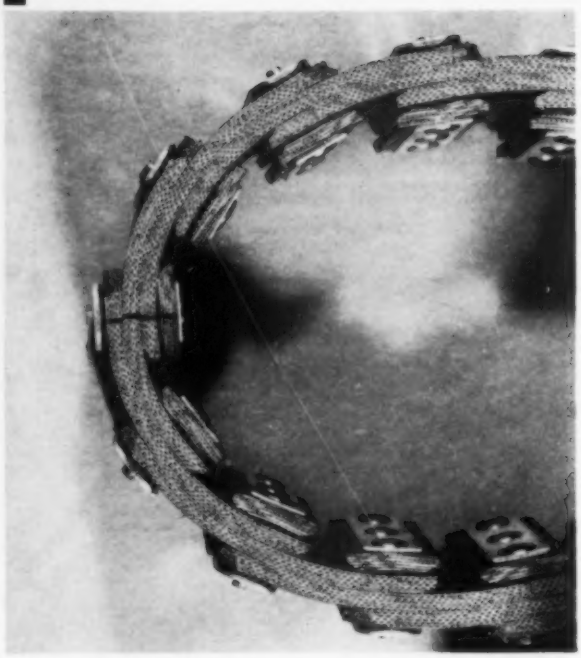
FLAT BELTS
for adjustable-pitch pulleys

Link V-belts combine lateral stiffness and lengthwise flexibility with helpful vibration-absorbing characteristics.

R G PROUTY
Manheim Manufacturing and Belting Co

Selection of a belt for a variable-speed pulley presents several special problems. To allow for the change in spacing of the pulley flanges, the width of the belt must be much wider than for a standard V-belt. But thickness cannot be increased in proportion or the belt will be too stiff to go around the pulley at its minimum-diameter setting.

Belt life varies with the abrasive effect of slip between the side of the belt and the pulley face, and the tension required to keep slip at a satisfactory value. Heat generated by internal friction may also be a factor,



Two views . . .
show how segmented belt works. When bent around small-diameter pulleys, relative movement between links increases flexibility and also tends to absorb vibration.

and vibration caused by nonuniform belt section may affect bearing life and performance of the machine as well as quality of finished work.

The problem therefore is to combine high lateral stiffness with longitudinal flexibility, while maintaining sufficient pulley-contact area to keep wear at a low rate.

One familiar belt design for variable-speed pulley employs wood-cleated belts, with leather-faced ends in contact with the pulley. The cleats, bolted to a thin flat belt, supply lateral stiffness while the belt carries the tension load with good flexibility. Leather facings on the cleats give good life, but the construction is expensive and a joint has to be provided for installation.

Molded endless belts combining high lateral stiffness with longitudinal flexibility are produced in several designs with lateral reinforcement and corrugations on inner or outer faces. One problem faced with such constructions is the change in section when running on the minimum diameter of the adjustable range. This change in section on a short radius tends to concentrate side contact pressure at areas that shift with radius of bend. Installation often requires dismantling.

A new approach to this problem employs the individual-link fabric belt assembled on studs in an adjustable overlapping pattern. Lateral stiffness is provided by metal plates attached to the studs by T-head screws. High flexibility in the longitudinal direction is obtained by thin belt segments or links. Shaped sides of each identical link maintain full contact with the pulley face at any pulley diameter.

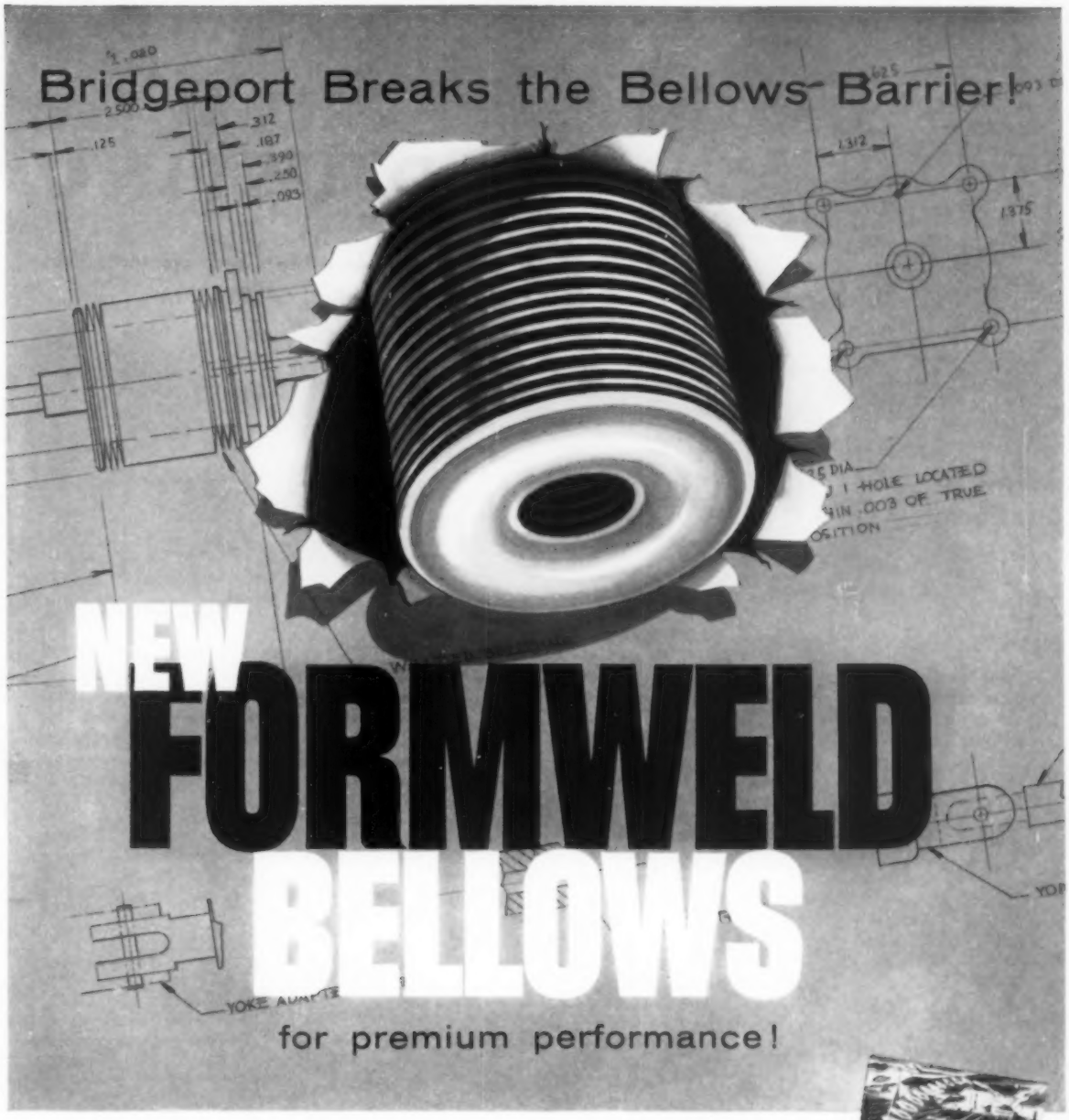
This construction can be adapted to any belt width from 1 to 5-in. top width. Three segments are overlapped to handle required tension loads. Any length can be assembled from stock widths, and a belt can be opened at any link for installation, removal, or adjustment of belt length.

Center distances for holes in individual segments are held to tolerances of 0.005 in., and the neoprene-impregnated fabric stock is held to a thickness tolerance of 0.005 in. Assembled belts are therefore of sufficient uniformity to substantially eliminate unbalance and vibration, which permits higher belt speeds than the cleated or solid belt. In addition, the relative motion between flexing segments tends to absorb vibration. Thinner sections in bending, plus the added flexibility at stud anchors, reduce the energy dissipated in flexing around small diameters.

In selecting a belt for a given adjustable-pitch drive sheave, the first step is to select a standard sheave of the diameter and width needed to transmit the required power at the speed range needed. Using the belt top-width and flange angle specified for the sheave, select a corresponding standard link. To determine the number of links multiply the outside circumference of the belt by the "tension factor" 0.543 and use the next larger whole number of links.

Cost of the assembled belt is generally comparable with solid belts. However, the cost of longer lengths tends to be somewhat less than for solid belts; also, in smaller widths, longer-link belts generally cost less.

EDITOR'S NOTE: "Belts for Power Transmission," Mid-Oct '57, p E26, shows a variety of belt forms, several with cogged or corrugated inner face. "Design of Belt and Wire Rope Drives," Mid-Sept '58, p E10, gives properties of belt materials and load capacities for V-belts and round rope drives in 45° or round grooves.



Now . . . you can confidently specify metallic bellows for even the toughest combination of environmental and service conditions . . . and get the most accurate and reliable bellows ever built!

Now . . . service limits are greatly increased by a wider choice of bellows metals, including Inconel-X, titanium, zirconium, Hastelloys, Monels, Ni-Span-C, 17-7 PH and 300 and 400 stainless steels, beryllium copper, super corrosion resisting and other weldable alloys.

Precision welding results in exacting control of dimensional tolerances on free length, I.D., O.D., parallelism of plates and end fittings, and concentricity of end fittings. Improved properties in FORMWELD Bellows include greater temperature, corrosion and fatigue resistance, ability to withstand higher loads without deformation, lower hysteresis with greater linearity, and complete uniformity of properties. More free plates per inch assure space savings. Available in sizes from ¼" to 18" plus O.D.

WRITE FOR BULLETIN A-7010

Mr. Controls

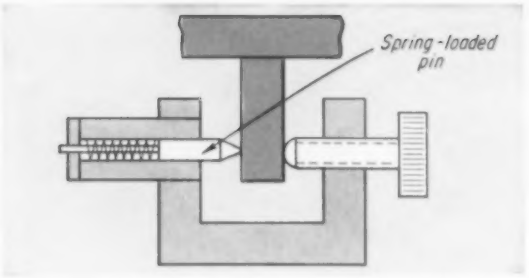
Robertshaw-Fulton
CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION
Milford, Connecticut

CIRCLE 127 READER SERVICE CARD 61

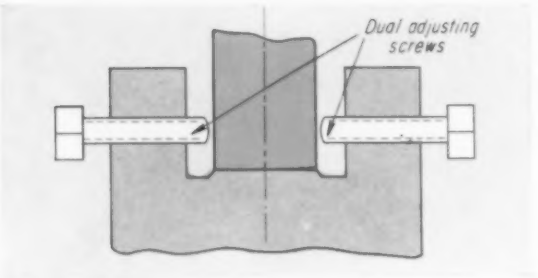
14 ADJUSTING

Here is a selection of some basic arrangements that provide and hold mechanical adjustment.



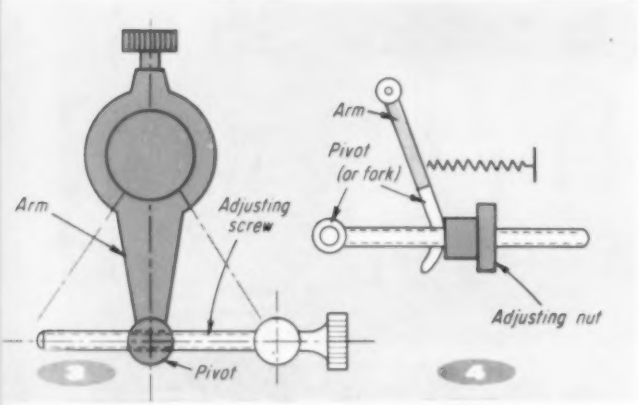
1

Spring-loaded pin . . .
supplies counterforce against which adjustment force must always act. A levelling foot would work against gravity—but for most other setups a spring is needed to give counterforce.

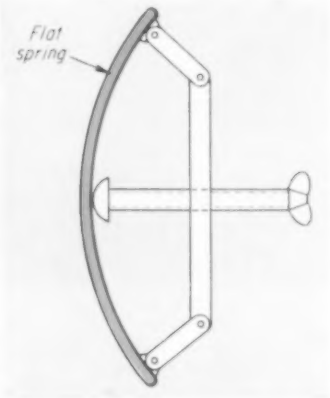


2

Dual screws . . .
provide inelastic counterforce. Backing-off one screw and tightening the other allows extremely small adjustments to be made. Also, once adjusted, the position remains solid against any forces tending to move device out of adjustment.

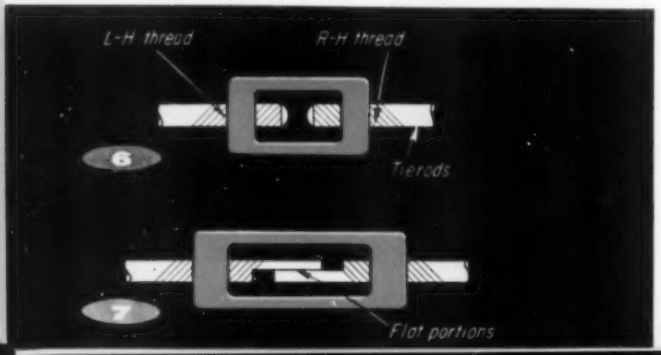


Swivel motion . . .
is necessary in (3) between adjusting screw and arm because of circular locus of female thread in the actuated member. Similar action (4) requires either the screw to be pivoted or the arm to be forked.



5

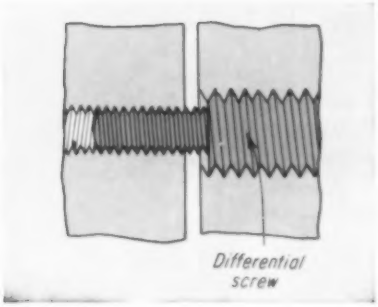
Arc-drafting guide . . .
is example of adjusting device where one of its own components, the flat spring, both supplies the counterforce and performs the mechanism's main function—guiding the pencil.



Tierods . . .
with opposite-hand threads at ends require (6) only a similarly threaded nut to provide simple, axial adjustment. Flats on rod ends (7) make it unnecessary to restrain both rods against rotation when adjusting screw is turned—restraining one rod is enough.

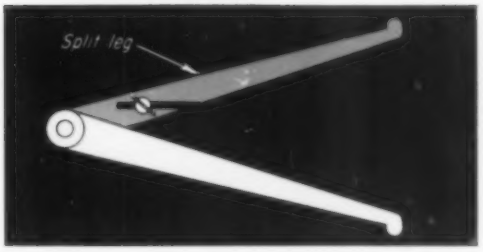
DEVICES

FEDERICO STRASSER, *Mankowitz & Strasser Ltd, Santiago, Chile*



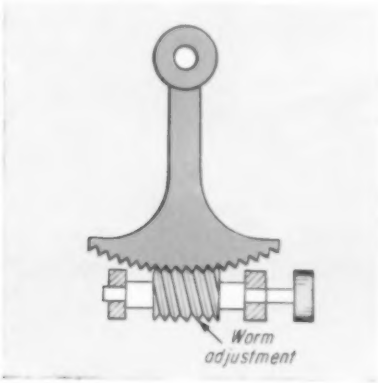
8

Differential screw . . .
has same-hand thread but with different pitches. Relative distance between two components can be adjusted with high precision by differential screws.



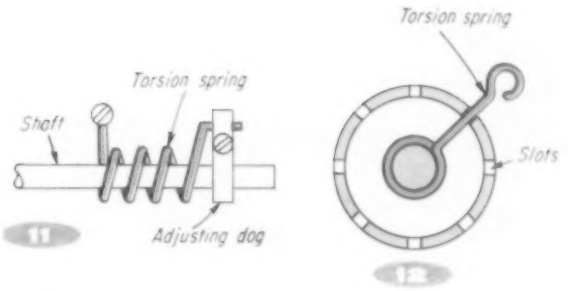
9

Split-leg caliper . . .
is example of simple but highly efficient adjusting-device design. Tapered screw forces split leg apart, thus enlarging opening betwen the two legs.



10

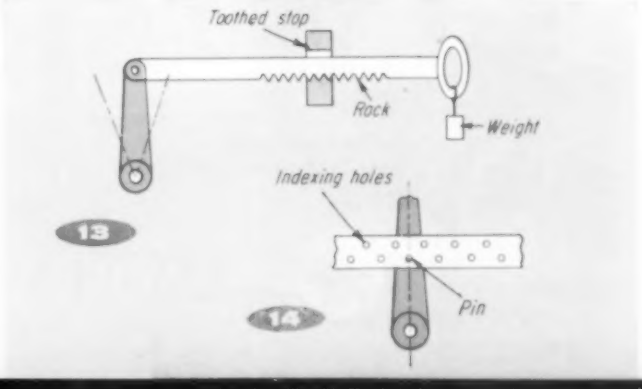
Worm adjustment . . .
is shown here in device for varying position of an arm. Measuring instruments, and other designs requiring fine adjustments, usually need this type of adjusting device.



11 12

Shaft torque . . .
is adjusted (11) by rotating the spring-holding collar relative to shaft, and locking collar at position of desired torque. Adjusting slots (12) accommodate torsion-spring arm after spring is wound to desired torque.

Rack and toothed stop . . .
(13) are frequently used to adjust heavy louvers, boiler doors and similar equipment. Adjustment is not continuous, depends on the rack pitch. Large counter-adjustment forces may necessitate weighted rack to prevent tooth disengagement. Indexing holes (14) provide similar adjustment to rack. Pin makes position less liable to be accidentally moved.



13 14

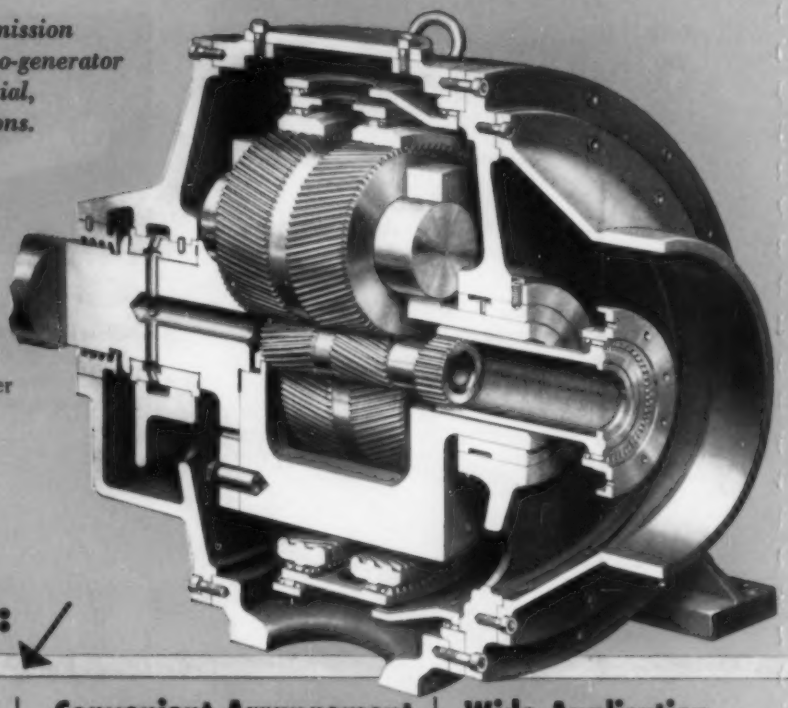
DE LAVAL-STOECKICHT
PLANETARY GEAR

...for high speeds...high horsepower

Proved in hundreds of installations abroad totalling over 3,000,000 horsepower—now available in America!

For all high torque power transmission applications such as pump turbo-generator and compressor drives in industrial, municipal and marine installations.

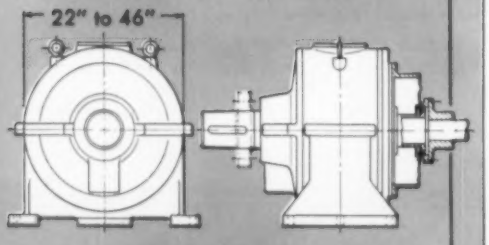
This cutaway view of the De Laval-Stoeckicht Planetary Gear shows how it provides flexibility for proper load distribution throughout the gear members. The thoroughly proved and tested design is completely reliable in transmitting high horsepower for high speed applications. • Highest efficiencies (98% or higher)...no high speed bearings...less friction losses.



Check These Advantages:

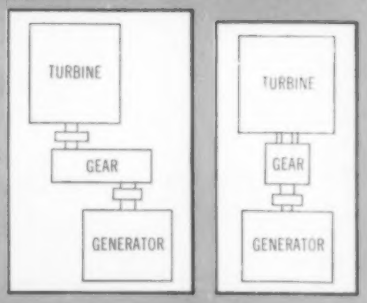
Small Size—Light Weight

Compact—low weight per hp. Sizes range from 22" to 46" in diameter, depending on horsepower requirements. Example: 5000 hp planetary unit weighs 1700 lbs. against 6000 lbs. for conventional gear.



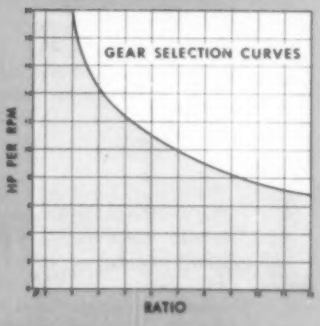
Convenient Arrangement

Co-axial or "in-line" arrangement of gear members takes up far less space than parallel axis gears of equivalent horsepower rating.



Wide Application

Capacity range shown in shaded area on chart below. For other applications, contact your De Laval Sales Engineer.



For further details, write for Bulletin 2400.

DE LAVAL *Steam Turbine Company*

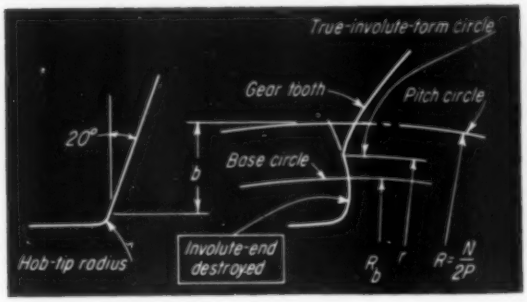
801 Nottingham Way, Trenton 2, New Jersey

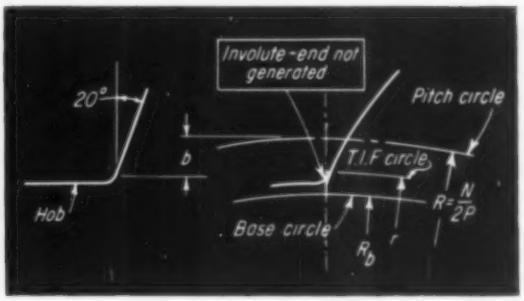
20° pressure-angle spur gears:

how to find the DIAMETER for TRUE INVOLUTE FORM

Two worked-out examples plus chart show whether the desired contour will be destroyed by undercutting, or not even generated if cutting isn't deep enough.

E A NIEMANN, Development Engineer, Minneapolis-Honeywell Regular Co., Minneapolis, Minn.





SYMBOLS

N = no. of teeth
P = diametral pitch
R = theoretical pitch-circle radius = $N/2P$
R_b = base-circle radius = $R \cos 20°$
r = ½ of the true-involute-form dia
b = distance (varies with tolerances and other factors) between pitch circle R and outermost point on involute-generating portion of the hob (In example 1 it equals $A + C + D - E$)
A = standard hob addendum = $1.250/P = 0.3125$ in.
B = a modification produced by withdrawing or entering the hob from its standard position
C = max machining tolerance, 0.0025 in. (increases b).
D = max hob tolerance, 0.0028 in.
E = hob-tip rad. (0.075 in.) multiplied by (1-sin 20°)

When you know the point at which a gear-tooth involute ends, gear center distances and hob cutting-positions can be specified that will guarantee contact within the involute limits.

If the outermost hob point (on the involute-generating portion) passes through the point where the base circle and the pressure line are tangent, the resulting tooth involute will be exact all the way to the base circle. If, however, the same point on the hob is closer to the workpiece center, the inner end of the generated involute will be destroyed by undercutting; move the hob point farther from the center and the involute inner-end will not be generated.

The chart on the continuing page gives ratio values that will show how far from the base circle the involute form ends—and therefore indicate the best production set-ups. The following examples show the chart in action.

EXAMPLE 1

Given: Pinion with 10 teeth and standard addendum

Diametral pitch, 4
Test-radius tolerance, C $^{+0.0000}_{-0.0025}$ in. $^{+0.0028}_{-0.000}$ in.
Hob-addendum tol, D
Hob tooth-tip radius, $\frac{0.300}{P} = 0.075$ in.

Find: True involute form dia.

$$b = 0.3125 + 0.0025 + 0.0028 - 0.075\,(1 - \sin 20°) = 0.2685$$

$$b/R = 0.2685 \div \frac{10}{(2)\,(4)} = 0.2148$$

From chart, $\frac{r - R_b}{R_b} = 0.0075$

(This value may be read from either of two curves cut by the 0.2148 abscissa, provided the correct scale factor is used.)

$$r = 0.0075\,R_b + R_b = 0.0088 + 1.1746 = 1.1831 \text{ in.}$$

In this example, 0.0088 radial in. of the involute inner end has been destroyed. To maintain the involute complete to the base circle, the hob should be withdrawn from the standard position by an amount $B = 0.122$ in.

(Continued on page 67)

MULTI-FLEX

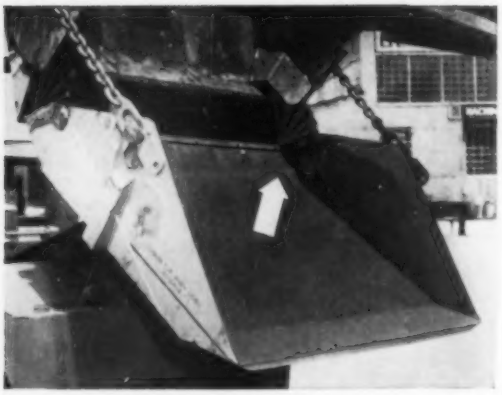
Which Multi-Flex application best solves your engineering problem ?

Here are just a few examples of the versatility that corrugated U. S. Multi-Flex® offers the equipment manufacturer.

Because Multi-Flex is specially engineered of rubber and fabric—*and not molded*—it has a built-in ruggedness that provides compression or extension without stretch or strain of the wall structure. It is available in a wide range of diameters and shapes, or can be engineered to your specifications. Inside diameters range from ¼" to 36", in constructions for service from minus 65 degrees to plus 500 degrees F.

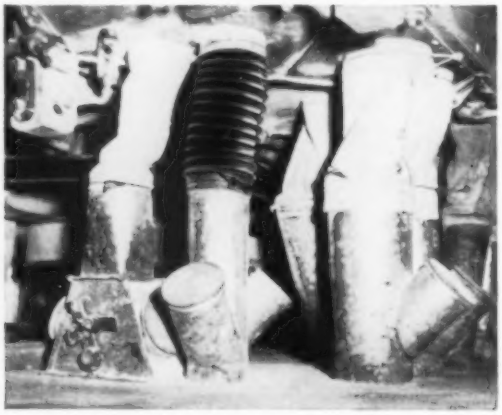
Get in touch with your "U.S." Distributor, any of the "U.S." Branch Offices, or contact us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

U. S. Multi-Flex is available in a wide range of diameters and shapes, or can be engineered to your specifications.



On this Dempster-Dumpster, Multi-Flex flat pleated sheet—acting as an accordion closure sealing an arc—combines a rubber-and-fabric strength to resist gouging and abrasion.

Multi-Flex connectors are used on this vacuum filter, taking care of axial movement and misalignment. They are especially valuable where conventional connectors will not take the required movement. Connectors can convey liquids, gases or granular solids.



In this flour sifter, Multi-Flex boots function as sifter socks conveying sifted flour to the bin. Circular motion of the sifter requires extreme extendability of the socks. Multi-Flex solves this problem and far outlasts fabric socks.

Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

TRUE INVOLUTE FORM (cont.)

EXAMPLE 2 (tolerances not included)

Given: 31 teeth, 48 P, standard addendum, hob tooth-tip radius is 0.0041 in.

$$b = \frac{1.2}{P} + 0.002 - 0.0041\,(1 - \sin 20^\circ)$$

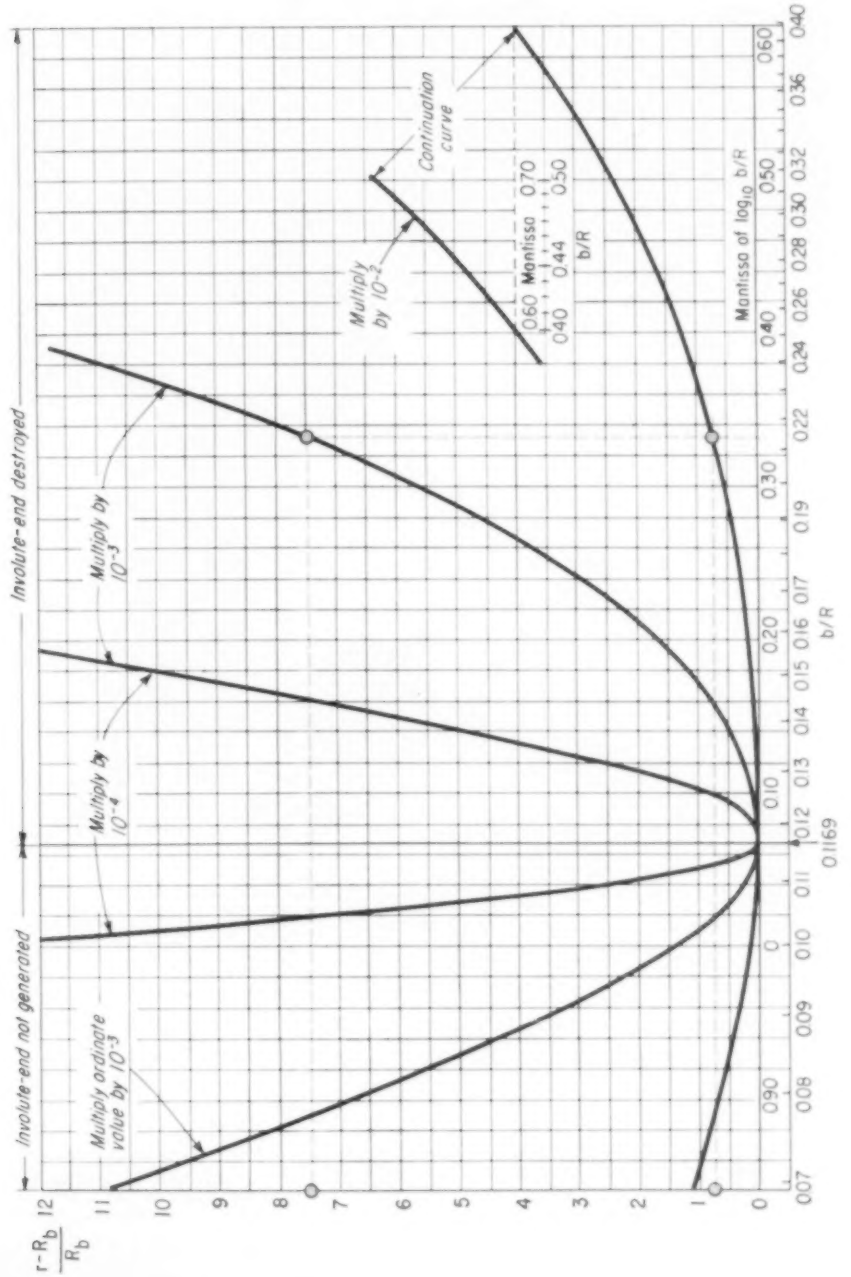
$$= 0.0243$$

$$b/R = 0.0243 \div \frac{31}{(2)\,(48)} = 0.07526$$

$$\frac{r - R_b}{R_b} = 0.84 \times 10^{-2} \text{ or } 8.40 \times 10^{-3} = 0.0084$$

$$r = 0.0084\,R_b + R_b = 0.00255 + 0.30344$$
$$= 0.30599 \text{ in.}$$

In this example, 0.00255 radial in. of the inner end of the involute has not been generated. To maintain the involute complete to the base circle, hob should be moved in from the standard position by an amount $B = 0.0134$ in.



creative designing calls for an open mind

Leonardo Da Vinci's design for an odometer

Model courtesy of IBM

EVEN DA VINCI'S ODOMETER COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

An SKF engineer can afford to concentrate on your bearing problem rather than his own product line—because the SKF line includes all four types of ball and roller bearings in many thousands of sizes. This gives him the kind of flexibility he needs to keep an open mind on any bearing problem. Give your problem to SKF and see. 7836

Spherical, Cylindrical, Ball, and Tyson *Tapered Roller Bearings*

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF

Friction-material adhesives . . .

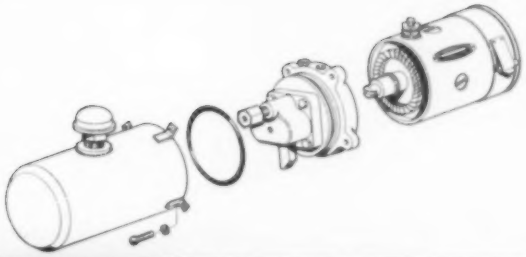
are said to have a shear strength of 495 psi at 600 F, compared with about 200 and 220 psi for other synthetic-rubber, phenolic-resin-base adhesives on the market. Three compounds are all thermosetting and differ only in percentages of solids they contain, providing choice of viscosities. Said to be resistant to oils, brake fluids, solvents and water, to have resiliency and to withstand shock. Adhesives are $3.70 and $4.75 per gal. in 55-gal. drums, depending on viscosity. From stock. **Adhesives Dept, Raybestos-Manhattan Inc, Bridgeport 2, Conn.**

Circle 1, Reader Service Card

Welder for light-gage metals . . .

operates on stored-energy principle, discharging current and end-welding studs and fasteners of $\frac{3}{16}$ in. dia max in 0.006 sec. Will handle various combinations of ferrous and nonferrous metals (to 28 gage), including high-polished stainless steel and coated or enameled sheet, without distortion, warping, burn-through or discoloration to grain and polish. The 2½-lb portable hand tool holds stud and closes circuit to discharge current when placed against work surface. Power unit weighs 144 lb and is equipped with 4-in.-dia wheels for portability. Average welding rate of studs or pins is said to be 6 to 8 per min. Power plant operates on 115 or 230 v ac, single phase, 60 cps. Welding unit is available from stock. Approximately $1300. **KSM Products, Merchantville 8, NJ.**

Circle 2, Reader Service Card



Self-contained hydraulic power . . .

package incorporates an electric motor, hydraulic gear pump with integral relief valve, check valve and reservoir. Designed to handle a wide variety of workloads, even as great as those encountered in snow plows, tailgate loaders, tractors and lift trucks. Capacity of pump ranges from 0.36 to 0.80 gpm. Reservoir, which also serves as pump housing, is available with capacities ranging from 0.43 to 1 gal. Motor may be ventilated, totally enclosed or standard starter type. Available for operation from a 6-, 12- or 24-v dc source. **Wooster Div, Borg-Warner Corp, Wooster, Ohio.**

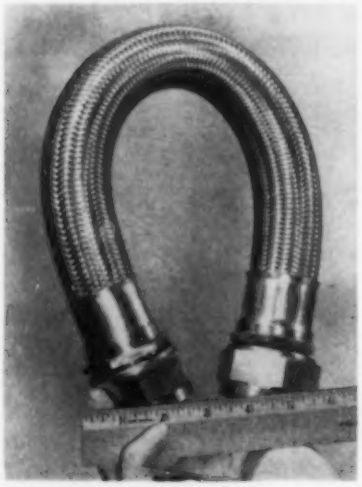
Circle 3, Reader Service Card

Plastic-film dust boot . . .

for protection of reciprocating rods, is hermetically sealed and can be installed on existing air or hydraulic cylinder without increasing space requirements. Thirteen convolutions in less than ¾-in. space, including end connections, are possible. When transparent plastic is used, oil leakage is trapped and made evident. End connections are designed to permit breathing, but boot can be fully sealed if a hose connection to a suitable vent or expansion chamber is provided. Round, square, rectangular or other shapes are furnished to specific requirements. Bellows in photo, with 13 convolutions, 1-in. ID × 3-in. OD, costs about $3.50 in 100-unit quantities; 2 to 3-wk delivery after approval of specs. **A F Gagne Associates, 50 Wall St, Binghamton, NY.**

Circle 4, Reader Service Card

. . . CONTINUED ON PAGE 70



Teflon hose assemblies . . .

with a min bend radius of 3¼ times the tube size is for high-temperature and corrosion resistant applications. If bent below min bend radius, hose flattens, but returns to original shape without damage to inner tube or braid when straightened out. Temperature range is from −65 to 400 F. Recommended working pressure for nominal sizes ¾ to 2 in. is 500 to 250 psi max. Pressure drop is said to be held to a minimum. Available in lengths up to 25 ft. **Titeflex Inc, Hendee St, Springfield 4, Mass.**

Circle 5, Reader Service Card

Transistor-equipped relay . . .

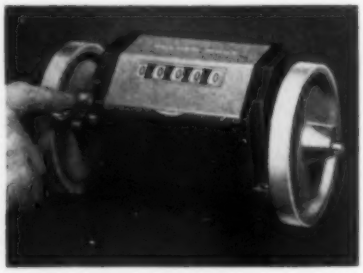
employs an electronic timing system for fast switching action, instantaneous reset, timing accuracy within 10% of specified time delay, and full repeatability of the time-delay period even during rapid recycling. Relay uses R-C network that serves only as a time pilot for transistor-equipped control circuit, which in turn operates a high-speed electromechanical switching unit. Operates in temperatures of 0 to 130 F. Available with standard fixed or adjustable time delay periods of 1.5, 5, 10, 15, 20 and 30 sec. Switching is SPDT and models operate on 12 v dc. Contact capacity on resistive loads is 2 amp at 120 v ac; 1 amp at 250 v ac; 0.5 amp at 50 v dc. Weighs 8 oz. **Heinemann Electric Co, 713 Plum St, Trenton 2, NJ.**

Circle 6, Reader Service Card

Miniature servovalves . . .

for 300- to 3000-psi hydraulic service offer flow ranges from ½ to 5 gpm with 1000-psi drop. Servovalve first and second stages can receive and pass on particles of 200 microns max without malfunctioning. First-stage hydraulic preamplifier has only one source of oil and, therefore, cannot become unbalanced as a result of oil contamination. Frictionless, high-gain, push-pull force feedback servo controls the second stage. Hermetically sealed torque motor is isolated from hydraulic fluid. Hysteresis is 1%; resolution, 0.1%. Weighs 11 oz. **Raymond Atchley Inc, 2340 Sawtelle Blvd, Los Angeles 64.**

Circle 7, Reader Service Card



Quick-reset counter . . .

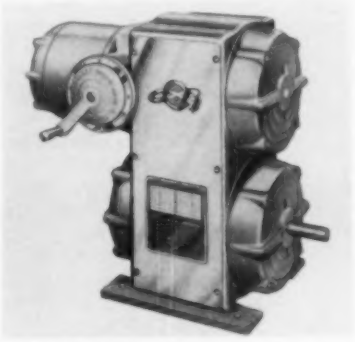
accepts speeds to 6000 rpm or 8000 counts per min. Resets to zero by flicking lever through 60° arc. Geared revolution counter is 5 x 2⅝ x 2⅛ in. high. **Veeder-Root Inc, Hartford 2, Conn.**

Circle 8, Reader Service Card

Wide-range transducer . . .

converts input pressures of 0 to 1000 psia into direct electrical output as an audio signal with a frequency inversely proportional to applied pressure. In operation, a vibrating wire is stretched between an anchor point and a pressure-sensitive metal diaphragm. Wire is set into motion in a permanent magnetic field by alternating current supplied by an associated amplifier connected in an oscillator circuit, frequency of which is controlled by vibrating frequency of stretched wire. Pressure changes are reflected by frequency changes in the wire. Output is furnished for measurement, telemetering, control or direct digital data processing. **BJ Electronics, Borg-Warner Corp, 3300 Newport Blvd, Santa Ana, Calif.**

Circle 9, Reader Service Card



1- to 20-hp mechanical drive...

offers infinitely adjustable speed over ranges up to 8:1 with output speeds of 1 to 10,000 rpm. Operates from ac power source. Basic components can be rearranged for vertical or horizontal mounting on floor, wall or ceiling; location of output shaft and motor in any of four positions; position of speed adjuster. Drives supplied with single or double reduction gears can have gear ratios changed in the field. Power from constant-speed, squirrel-cage induction motor is transmitted by adjustable diameter disks and a ribbed belt. **Louis Allis Co, 427 E Stewart St, Milwaukee 1.**

Circle 10, Reader Service Card

Heat-resistant fabric . . .

originally developed for diaphragm applications in gas regulators and controls is said to be about 100% more heat-resistant than conventional Buna-N coated diaphragm fabric. Nylon fabric is coated with Buna-N that is compounded for elevated temperature resistance. Fabric is also said to have resistance to oils, solvents and gas condensates. Available in 0.006 in. to 0.050-in. thickness in widths from 36 in. up for general distribution. **Reeves Bros Inc, 1071 Ave of the Americas, New York 18.**

Circle 11, Reader Service Card

Miniature flexible coupling . . .

employs a replaceable molded nylon disk to transmit torque and to absorb shock; and parallel and angular misalignment. Couplings are offered in three stock sizes,

. . . CONTINUED ON PAGE 72

ANALYSIS — Kaydon studies every pertinent bearing requirement, such as speed, load, safety, operating and fatigue life factors.

DESIGN — Kaydon engineers bring an unequalled fund of knowledge and bearing design experience to your project.

MANUFACTURING AND TESTING — Complete, modern fabricating facilities . . . precision control of all quality factors.

custom engineering

KAYDON custom bearing designers can prove or improve your product

Why penalize product performance success with "make-do" bearings? Kaydon's long experience points out that standard bearings often *won't do*, aren't always efficient or economical.

Kaydon engineers creatively design, develop and manufacture special, modified, and standard ball and roller bearings. All-new Kaydon "idea bearings" or modified types will help you *prove* your new product designs; *improve* your redesigns. Kaydon can incorporate millionth's-of-an-inch precision, light weight or super-rugged construction to exactly match the bearing to your application.

Send us sketches or scale prints of your bearing problem. *There's no obligation.*

Typical Kaydon-developed special bearings

World's largest precision ball bearing (165") designed and built by Kaydon, rotates radar antennae.

World's thinnest radial ball bearing — Kaydon "Reali-Slim," 12.00" I.D., 12.500" O.D., .250" thick.

World's newest Thin-Shell Needle Bearing — for automotive and industrial use.

World's lightest large aircraft wheel bearings 9/16" cross section.

THE KAYDON ENGINEERING CORP.

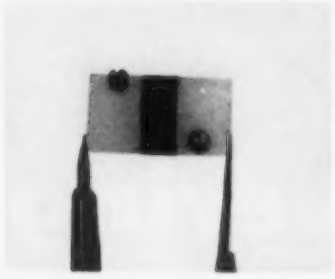
MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller •Roller Thrust •Roller Radial •Needle Roller •Ball Radial •Ball Thrust Bearings.

K-581

rated ⅛, ¼ and ½ hp at 1750 rpm. Over-all dimensions of the largest is 1½ x 1¼ in. dia. To permit free-floating action of nylon center member, two jaw hubs of cold-rolled steel are locked to driver shafts by cup-point setscrews. Stock bores are $\frac{5}{16}$ to $\frac{3}{8}$ in. by $\frac{1}{16}$-in. increments, with tolerances held to plus 0.001 in., minus 0. **Climax Metal Products Co, 863 E 140th St, Cleveland 10.**

Circle 12, Reader Service Card



¾-in. flexible coupling . . .

for power transmissions weighs 1½ gm, has 0.400 in. OD. Standard shaft sizes are ⅛, $\frac{5}{16}$ and ¼ in. No assembly clearance is required between Zytel nylon end-fitting and rubber flex-element. Composition and dimensions of flexing element can be varied. **Guardian Products Corp, Dept 42, 1215 E 2nd St, Michigan City, Ind.**

Circle 13, Reader Service Card

Solenoid shift motor . . .

has internal solenoid that engages rotor and gear train immediately when motor is energized and acts to permit train to run freely when motor is de-energized. Offered in speeds between 1 and 180 rpm. Output torque is rated 9 in.-oz at 1 rpm. Dimensions are 1 21/64 x 2 in. dia. **Bristol Motors, Old Saybrook, Conn.**

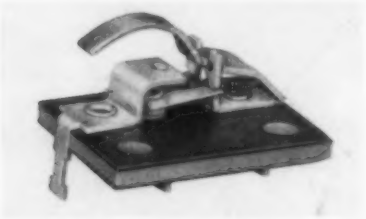
Circle 14, Reader Service Card

Zippered cable cover . . .

withstands 2000 F continually and 3000 F for brief periods. Aluminized reflective asbestos jacket is closed by a plastic or metal zipper track stitched to fiber with Teflon thread. External flap protects track. Available in sizes from ½-in. ID up, in increments of ⅛ in. in standard lengths of

25, 50 and 300 ft. Can be zipped over cables, components, hoses, wires and tubing to eliminate damage from high temperatures, flames or sparks at a reported rate of 20 fpm. **Zippertubing Co, 752 S San Pedro St, Los Angeles 14.**

Circle 15, Reader Service Card



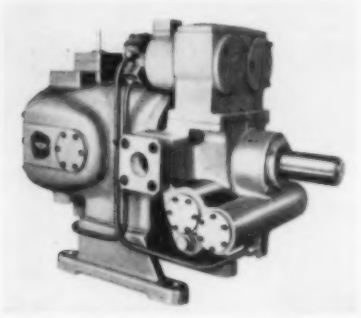
Snap-action cam switch . . .

offers long life and accuracy for linear cam, rotary and rotary pin actuation. Designed to accept clockwise and counter-clockwise cam actuation with equal precision. Positive stop protects mechanism from damage due to excessive overtravel. Operating force can be varied from 2 to 7 oz. Rated 10 amp at 125 v ac, 5 amp at 250 v ac, ¼ hp at 125 or 250 v ac. Can be gang-mounted for control of multiple circuits. Price is 21¢ each for 10,000 units, **Cherry Electrical Products Corp, 1650 Deerfield Rd, Highland Park, Ill.**

Circle 16, Reader Service Card

Axial piston pumps . . .

and motors for control of speed, torque, reversal, acceleration or deceleration, meet specifications of MIL-P-17869. Three series are built in constant and variable-volume types rated for pressures of 3500 psi at 1200 rpm and intermittent overloads to 4500 psi. Over-all mechanical efficiency at full load is said to be 92%; volumetric efficiency, 96%. Pumps, designed to reverse direction of output flow, can be equipped as variable volume units. All three series pumps are of cross-center



design for closed-circuit operation with an integrated accessory package built into pump inself. Integrated fluid motors have rated torque of 123.6, 179.7 and 373 in.-lb per 100 psi. Displacement ranges from 7.77 to 23.45 cu in. per rev. **Denison Engineering Div, American Brake Shoe Co, Columbus, Ohio.**

Circle 17, Reader Service Card

Tubing and tap valves . . .

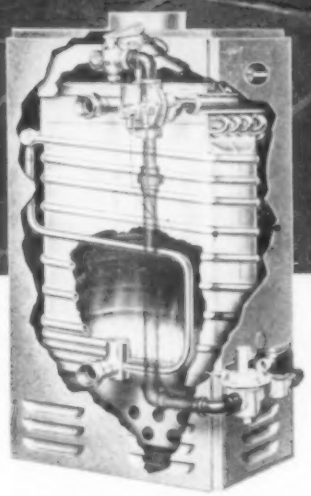
are suitable for use with aluminum, copper or steel tubing. **Henry Valve Co, 3215 North Ave, Melrose Park, Ill.**

Circle 18, Reader Service Card

4-way dual-seal valve . . .

in ¼, ⅜ and ½-in. port sizes has circular-flow design said to increase rated capacities. Direct operation, shorter stroke and fast response are features of lightweight valve, which is reported to have been tested at better than 40 million cycles. Solenoid and spool-within-a-spool design has only three moving parts. Fewer operating parts and reduced size and weight have resulted in lower production costs and lower cost valves. Standardized and add-a-unit interchangeable manifold bases permit grouping of from 2 to 10 valves.

. . . CONTINUED ON PAGE 74



How To Take The Cool From The Pool With Bridgeport Brass and Copper

A back-yard swimming pool is great fun but often the season seems too short. Today, with a pool heater, you can extend the pleasure of the swimming season from early spring to late fall. One of the leading units of this type is the M/E Universal Heater which supplies automatic instant heat to pool water. The manufacturers, McIntyre Engineering Co., of San Francisco, rely on Bridgeport metals for greater efficiency and dependability in their product.

The M/E Universal is a gas-fired instant heat boiler which keeps swimming pool temperatures at a comfortable 76°. Forming the unit's combustion chamber is Bridgeport copper sheet. Water circulates around the chamber through $\frac{5}{8}$" soft temper Bridgeport copper tube brazed to the sheet, and into a fin-and-tube copper coil at the top.

Copper, of course, is a natural for this kind of equipment. Its resistance to corrosion and excellent thermal conductivity make it especially desirable where heat and moisture are factors. Pool heaters are only one application in which brass and copper perform as no other metal can.

Bridgeport supplies high-quality brass, copper and bronze in a wide range of alloys and forms. Call your nearest Bridgeport Sales Office for help with your product and production needs, or wire us directly at the address below.

Bridgeport BRASS CO. **BRIDGEPORT BRASS**

Bridgeport Brass Company, Bridgeport 2, Conn. Sales Offices in Principal Cities. In Canada: Noranda Copper and Brass Limited, Montreal

ACME CHAIN

NOW OFFERS
LARGEST SELECTION OF
FINISHED BORE SPROCKETS

99 Sizes
433 Different Bores

OFF THE SHELF SERVICE

- *Complete with standard keyway and setscrew*
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- *Marked for easy identification and handling*
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- *A terrific saving in time and money — reduces down time — reduces maintenance cost — increases life of drives*

ACME finished sprockets are stocked in single widths from ⅜" to 1" pitch inclusive. 99 Sprocket tooth sizes with more than 433 different bores provide a wide selection range.

All finished bores are completely machined. Bores are accurately finished and are concentric to sprocket pitch and bottom diameters within A.S.A. standards.

Acme also carries a complete line of sprockets such as Grip-Master and Stock Sprockets.

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Write for Bulletin No. 3 listing all sizes and prices.

Call ACME for Service

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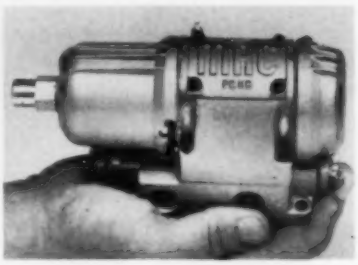
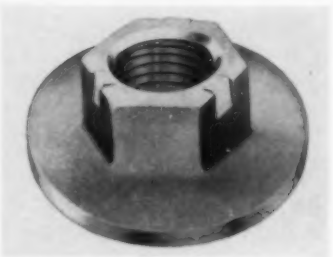
COMPLETE LINE OF ROLLER CHAINS AND SPROCKETS • DOUBLE PITCH CONVEYOR CHAINS • STAINLESS STEEL CHAINS • CABLE CHAINS • FLEXIBLE COUPLINGS • STANDARD AND SPECIAL ATTACHMENTS



Combined, bases form a single inlet, single exhaust and single conduit channel. Integral conduit boxes connected by wiring channels and plug-in wire lead connectors are standard. **Mechanical Air Controls Inc, 10030 Capital, Oak Park, Detroit 37.**

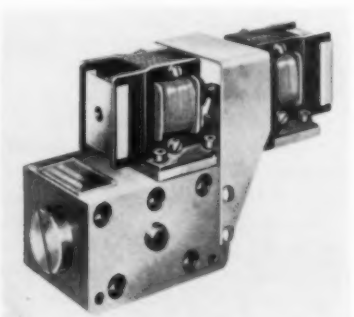
Circle 19, Reader Service Card



Washer-base locknuts . . .

lock any place on a screw or bolt. One-piece, hexagon washer-nut eliminates need for separate flat washer. Available in sizes No. 10 through ½ in. Recommended for shock mountings, for retaining spring coils or for other applications where an object must be held in a fixed position under tension. **Shakeproof, Div of Illinois Tool Works, St. Charles Rd, Elgin, Ill.**

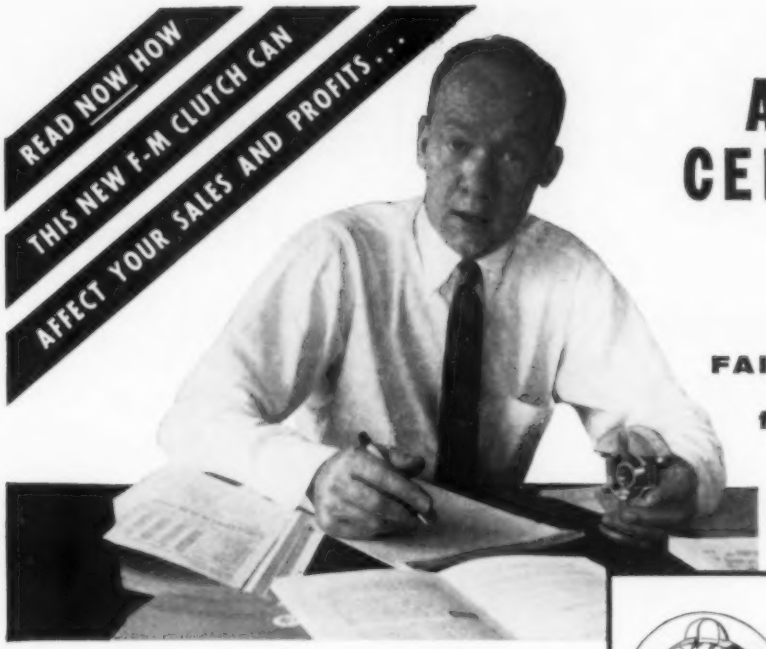
Circle 20, Reader Service Card



¼-in. hydraulic valve . . .

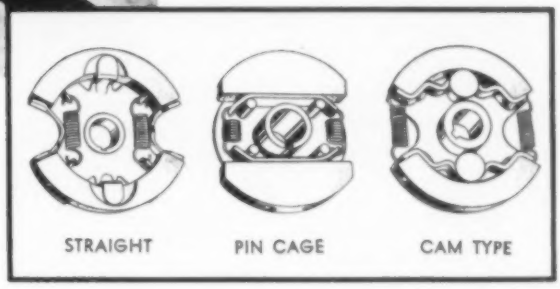
remotely controls direction of flow of 3½ gpm at 1000 psi. Four-way, 2-position, detented, dual-solenoid-operated control valve is available in manifold or pipe tap styles. Mounts horizontally or vertically.

(Continued on page 78)



A NEW AUTOMATIC CENTRIFUGAL CLUTCH

designed by FAIRBANKS-MORSE for the toughest usage you can name



Substantial cost savings for companies who can use it!

Here's an idea for engineers who want to reduce costs for profit improvement.

Simple design and high-volume production of these new clutches for motors and small gasoline engines mean substantial savings to you. And your quantity requirements make little difference in the cost.

If your equipment does not incorporate this starting feature, think of the benefits. Smaller motors can be used for *running* rather than starting loads. It provides low-line voltage protection on jobs where transmission lines are not adequate. You get smooth, gradual pick-up, and the motor is never called on to deliver power below its maximum torque speed. Starting current demand is reduced. It's a foolproof safety device — protects against stalling or overloads, yet does not slip at operating speed.

Gasoline engines may be started easier. The load is automatically applied at the engine's most efficient speed. It prevents stalling and accidental equipment damage.

The new clutch is manufactured in three types — all can be used with a pulley, sprocket, gear, or coupling-type drive on machinery, appliances, and gasoline engine equipment — any application on which automatic start and stop applies. If you already make or buy clutches, couplings, or drives for no-load starting and idling or overload protection, write for Fairbanks-Morse prices and evaluate the cost savings.

- **Simple and dependable—only four moving parts**
- **Compact, no-maintenance design**
- **Proved long life on chain saws**
- **Operates in either direction**
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- **Smooth, low- or high-speed actuation**
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- **No slip at normal operating speeds**

Send coupon and application data, we'll send literature, recommendations, and prices.

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A name worth remembering when you want the BEST

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☐ Please send literature on automatic clutches.

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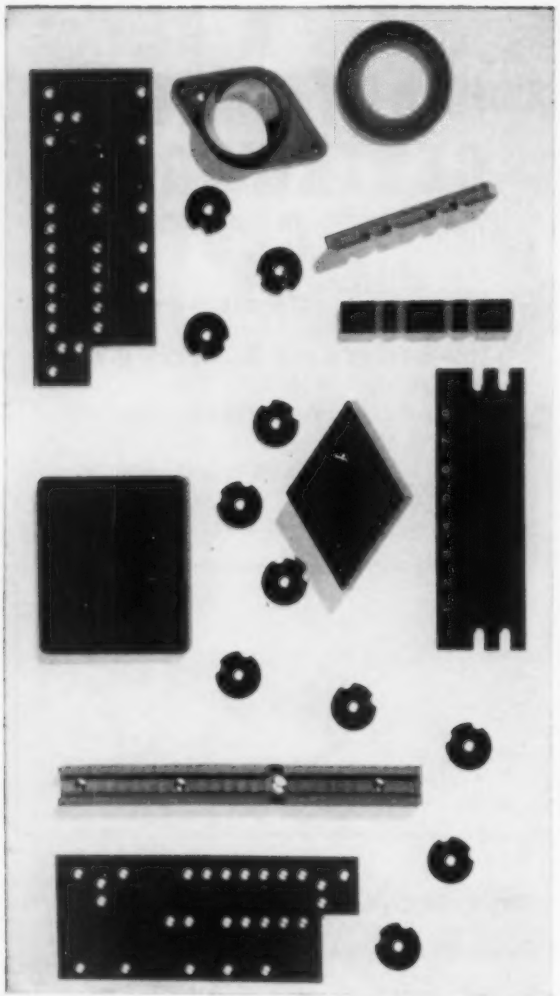
CIRCLE 134 READER SERVICE CARD 75

Nobody gives you as complete power



Fabricated by CDF. Near the presses that produced the Dilecto laminates, these paper-base parts were machined to close tolerances by CDF specialists . . . quickly, accurately, economically for the purchasers. This is a random selection from the five grades described in the table below.

CDF Dilecto® paper-base laminates for the workhorse insulation jobs

For everyday mechanical-electrical parts that receive tough punishment and must have excellent physical and dielectric properties at low cost, the CDF phenolic paper-base line is outstanding.

Economy. CDF paper-base grades machine readily into intricate parts. Some are flame-retardant. Others are especially adaptable for punching. All are economical for the value delivered.

Fabrication Facilities. CDF has excellent and extensive plastics-fabrication facilities for turning out finished Dilecto parts to your specifications—better and more economically than you can do it yourself. Save the time and trouble of intricate fabrication by using CDF's specialized facilities.

See Sweet's, Electronics Buyers' Guide, and the other directories for the phone number of the CDF sales engineer nearest you. Or send us your print or problem direct, and we'll return a recommendation of the right Dilecto grade for your need.

CDF makes Di-Clad* printed-circuit laminates, Diamond* Vulcanized Fibre, CDF products of Teflon†, flexible insulating tapes, Dilecto* laminated plastics, Celoron* molded products, Micabond* mica products, Spiral Tubing, Vulcoid*.

*Trademark of Continental-Diamond Fibre Corporation
†Du Pont trademark for its TFE-fluorocarbon resin

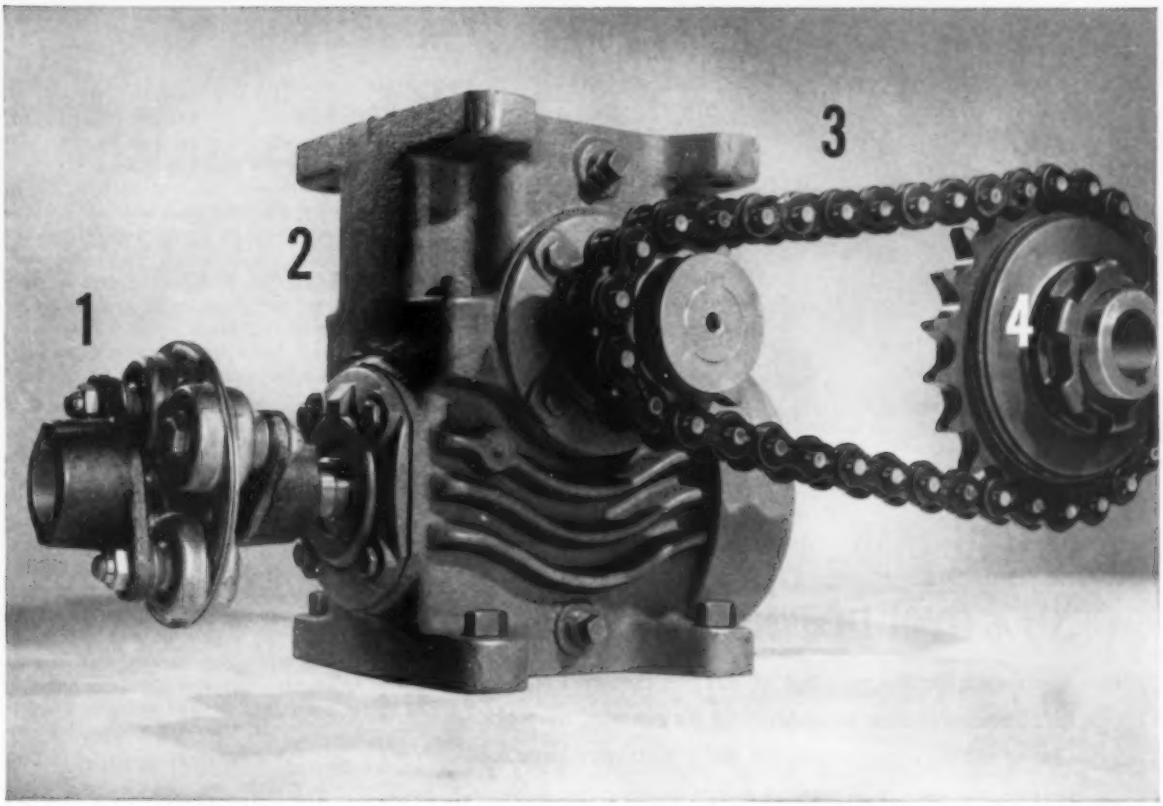
CONTINENTAL-DIAMOND FIBRE
A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 40, DEL.

Typical Property Values—Dilecto Paper-Base Laminates in Sheet Form

	X-13 (NEMA X)	XP-13 (NEMA P)	XX-13 (NEMA XX)	XX-13 FR (Fire-retardant) (NEMA XX)	XXXP-28 (NEMA XXXP)
ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16" thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

Nobody gives you as complete power transmission service as Morse, because . . .

Only Morse offers all four of these basic power transmission components



1 Couplings*

Morflex
Flexible Chain
Radial
Nylon
(*All available in driveshaft constructions)

2 Eberhardt-Denver Speed Reducers

PoweRgear®
Worm Gear
Helical
Gearmotors

3 Chain and "Timing"® Belt Drives

Roller Chain
Silent Chain
Hy-Vo® Drives
"Timing" Belt

4 Clutches

Torque Limiter
Cam
Overcenter
Pullmore

IN POWER TRANSMISSION THE TOUGH JOBS COME TO

MORSE MORSE B-W BORG-WARNER *Trademark

REMEMBER: The toughest jobs in power transmission come to Morse, because *only Morse* offers all four of these basic components . . . and backs them up with technical know-how based on over 60 years' experience solving power transmission problems.

MORSE CHAIN COMPANY, A BORG-WARNER INDUSTRY, Dept. 4-108, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois

SPECIAL SECTIONS did the job for

TRADE YALE MARK

Channel of Yale Industrial Lift Truck specially rolled to specification by Connors' West Virginia Works

Steel-in-use cost reduced 30% over previous methods

Hot rolled section pictured above was designed to fit Lift Truck's precise requirements. As a result, normal cost of rolling channel was cut 30%. You may have a manufacturing problem that our engineers can solve by designing special sections to your own specifications and tolerances. Expert engineering consultant service is available from Connors without charge.

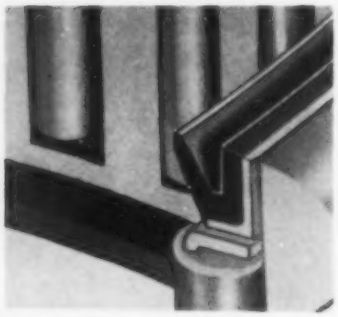
For technical bulletin *giving complete information, write Department DB, Connors Steel Division, P.O. Box 2562, Birmingham, Alabama.*

"Service and Quality"

H. K. PORTER COMPANY, INC.
CONNORS STEEL DIVISION

Has iron body and hard nitralloy stem, ground and lapped to fit. Dimensions are $8\frac{1}{8}$ x $3\frac{7}{16}$ x $4\frac{1}{2}$ in. high. Variations permit flexibility of application. **John S Barnes Corp, 301 S Water St, Rockford, Ill.**

Circle 21, Reader Service Card



Needle bearings . . .

have neoprene seals to exclude foreign matter, retain lubricant and act as a vent to prevent displacement if more lubricant is added. Two bearing lengths are available for each size from $\frac{1}{2}$ to 2-in. shaft dia to meet load, space and design requirements. Single or double seals are offered. From stock. **Orange Roller Bearing Co Inc, Orange, NJ.**

Circle 22, Reader Service Card

Size 10 servomotor . . .

is brake-equipped. Maintains a constant reference position in a servo system despite shock and vibration environment. Consists of standard servomotor with friction brake controlled by an electromagnet. Brake stops and holds motor rotor and shafts at any desired position, preventing rotor creep. May be used in automatic or manually actuated systems. Available in a variety of standard voltages. **Kearfott Co Inc, 1500 Main Ave, Clifton, NJ.**

Circle 23, Reader Service Card

Electrical footswitch . . .

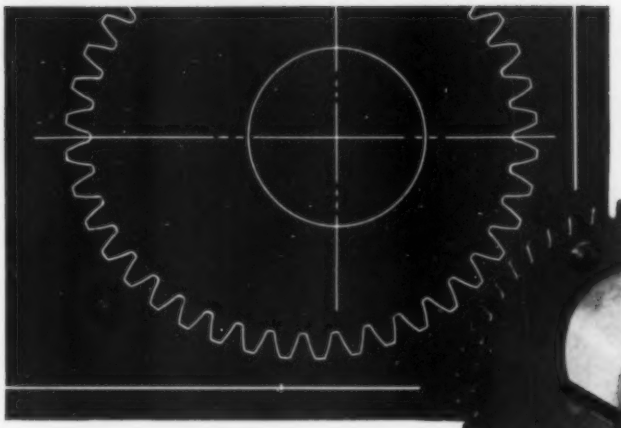
for operation of quick-action equipment and solenoid-controlled devices, without damage to solenoid. Impulse switch momentarily opens or closes circuit when depressed, regardless of depression time. Rated 15 amp, 125 v ac. Switch is SPDT. $2\frac{3}{4}$ x $3\frac{1}{2}$ x $\frac{7}{8}$ in. **Vemaline Products Co, Box 222, Hawthorne, NJ.**

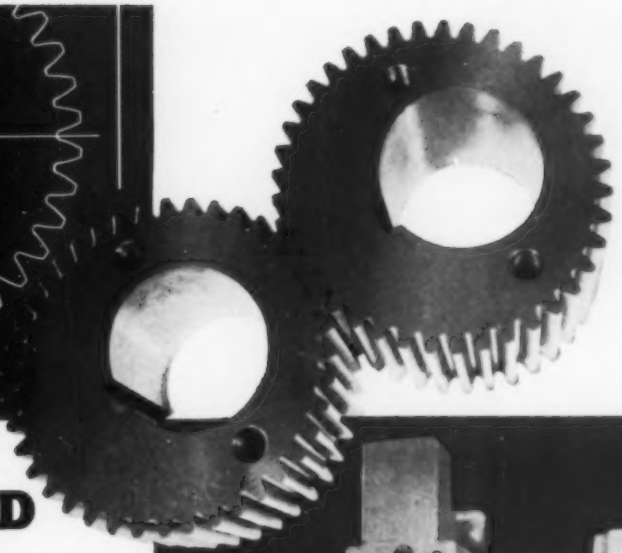
Circle 24, Reader Service Card

3-way solenoid, pilot valves . . .

use same type base and share same operating parts, permitting interchangeability and min stock of spare parts. Pilot valve

(Continued on page 82)



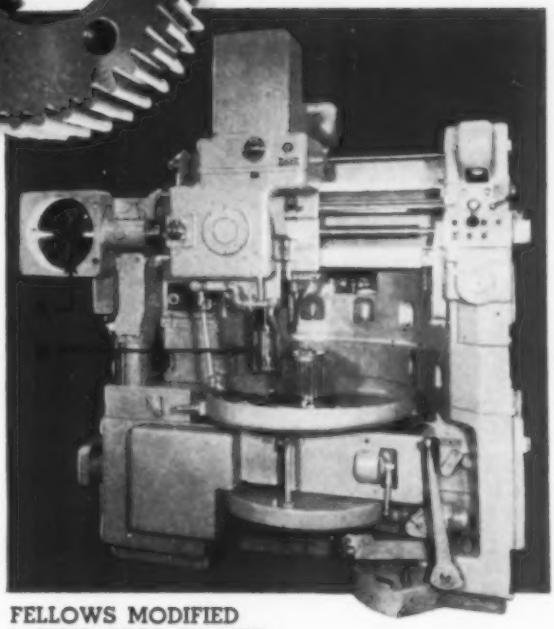


ELLIPTICAL AND OVAL GEARS

produced accurately and economically

Until now, owing to production difficulties, the design advantages of oval or elliptical gears have rarely been realized. Now Fellows has developed a unique method of generating these gears rapidly and economically. This new method minimizes the difficulty of wide variations in backlash experienced with such gears cut by previous methods. Full or modified involute teeth are produced to a higher degree of accuracy than was ever possible before on gears of this type. Production in any quantity is as simple as in cutting conventional cylindrical gears, once the setup has been made.

Fellows Modified 36-Type Gear Shaper generates elliptical or oval gears by continuously varying the center distance between cutter and gear during the cutting operation. A contour cam (A) and follower move the saddle the required amount in timed relationship with the rotation of the eccentric cutter-spindle adapter (B) to produce the gear pitch line contour.



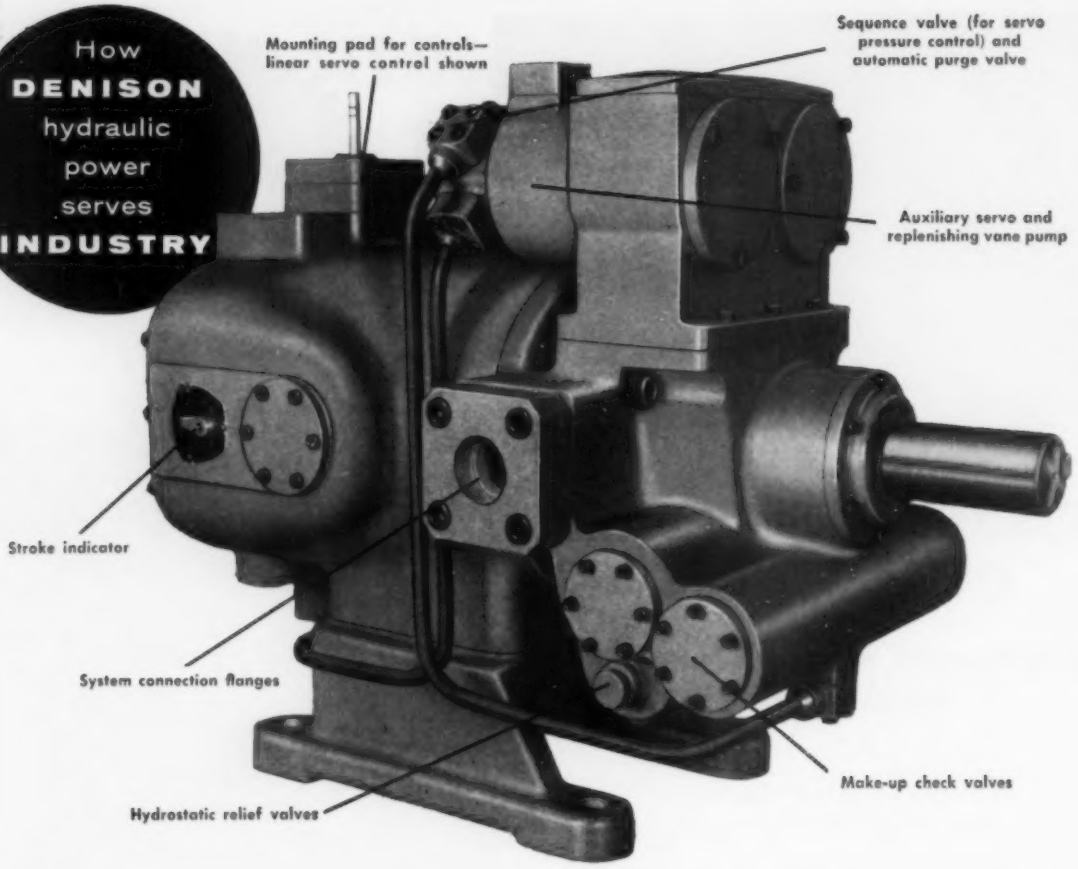
FELLOWS MODIFIED 36-TYPE GEAR SHAPER

In addition to *oval and elliptical gears* up to a maximum pitch diameter of 18", the Modified Fellows 36-Type Gear Shaper can produce a remarkable variety of *irregular contours* at high production rates. Two cams, a cutter-spindle adapter and a cutter are required for each gear or other shape specification. For further information, get in touch with any Fellows office.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE *Fellows* *Gear Production Equipment*

How **DENISON** hydraulic power serves **INDUSTRY**


Mounting pad for controls—linear servo control shown
Sequence valve (for servo pressure control) and automatic purge valve
Auxiliary servo and replenishing vane pump
Stroke indicator
System connection flanges
Make-up check valves
Hydrostatic relief valves

AXIAL PISTON PUMPS and MOTORS

For precision, split-second control of speed... torque... reversal... acceleration... deceleration

Series 30, 40 and 60

Constant and Variable Volume Pumps to 115 gpm
Fluid Motors to 373 inch-pounds per 100 psi
...for continuous service up to 3500 or 5000 psi

Denison's heavy-duty line of hydraulic Axial Piston Pumps and Motors offers important features and performance characteristics unexcelled in the hydraulic equipment field.

These Variable Volume Pumps are available as pre-built packages with built-in replenishing pump that provides supercharging . . . pressure control and forced circulation for cooling . . . plus relief and replenishing valves.

Axial Piston Pumps and Fluid Motors by Denison assure the kind of smooth, split-second, dependable operation required in today's most modern systems.

APPLICATIONS—Presses . . . transmissions . . . marine drives . . . missile ground support and handling equipment.

SPECIFICATION DATA

SERIES 30	SERIES 40
Constant and Variable Volume Pumps	**Constant and Variable Volume Pumps**
1200 rpm 3500 psi delivers 38 gpm	1200 rpm 3500 psi delivers 53 gpm
Fluid Motors	**Fluid Motors**
Torque—123.6 inch-pounds per 100 psi	Torque—179.7 inch-pounds per 100 psi

SERIES 60

Constant and Variable Volume Pumps
1200 rpm — 3500 psi delivers 115 gpm
Fluid Motors
Torque — 373 inch-pounds per 100 psi

OPERATING EFFICIENCY — Over-all mechanical efficiency at full load — 92%, Volumetric efficiency — 96%.

Other models for 5000 psi duty are available

Write for detailed Bulletins

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1194 Dublin Road • Columbus 16, Ohio

Denison Stocking Branch Offices: LOS ANGELES • CHICAGO
DETROIT • ATLANTA • HOUSTON • NEWARK • CLEVELAND

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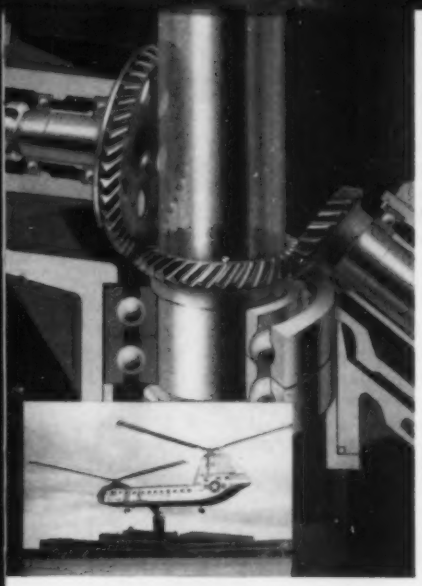
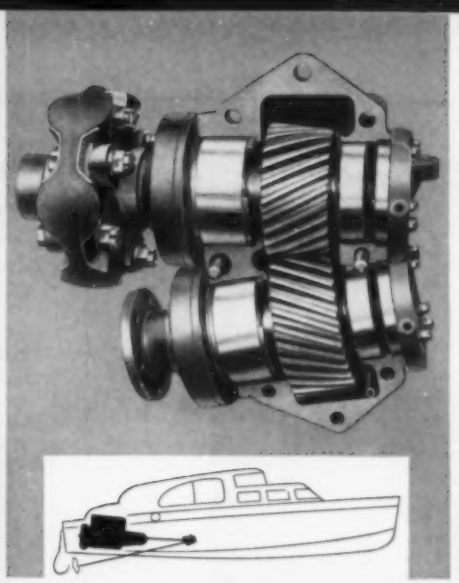
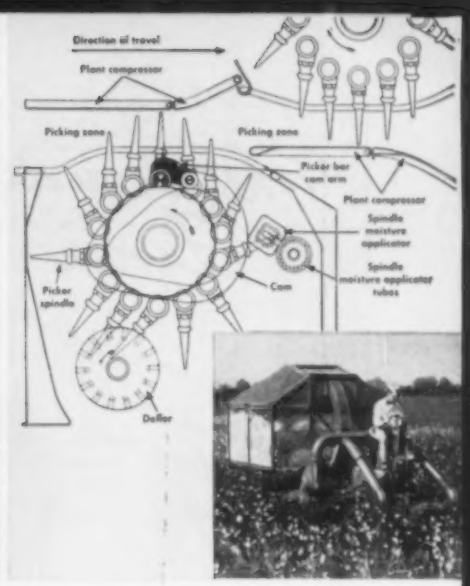
DENISON HydrOILics

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

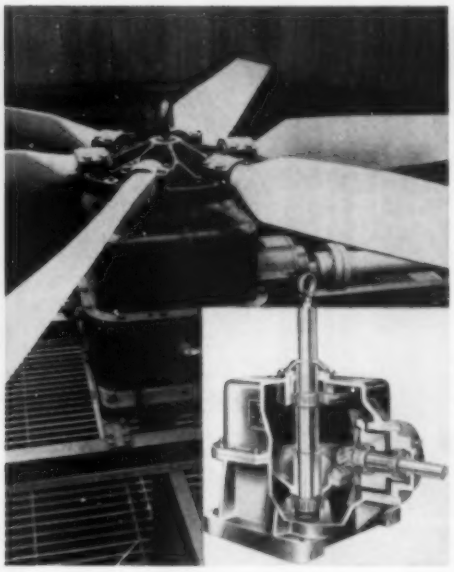


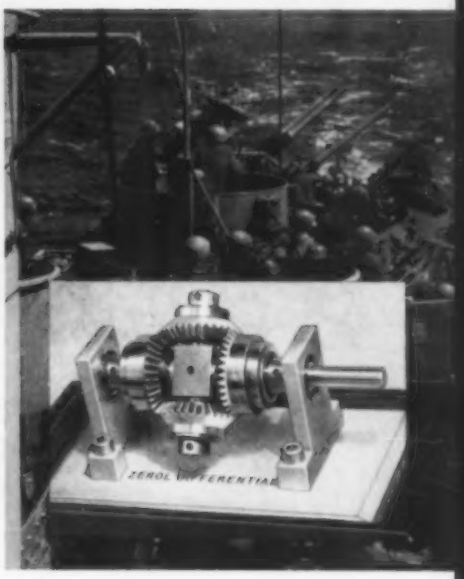




CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.

BEVEL GEARS





What happens when you use right angle or angular drives?

More flexibility. Instead of designing *around* your transmission, you can design a transmission *into* your products with angular drives.

The *helicopter*, for example, is made more compact by having a single drive source service both a blower and a pump. The drive on the *speedboat* gives better balance and more usable cabin space. The *cotton picker* runs fourteen separate picking spindles off one drive member.

Greater accuracy. Using Gleason machines and methods you can grind or cut bevel gears to exceptionally close tolerances. The complete accuracy and reliability needed in the *missile* and *fire control unit* are obvious.

Heavier loads. An angular drive can stay compact and still carry heavy loads such as the one on the gear reducer in the *cooling tower fan.*

Full engineering help. A large and competent staff of Gleason engineers is yours to call on for help in early design work, for the manufacture and testing of prototypes, for selecting and setting up of machines and methods, and for any other assistance you might need.

Free literature. To become better acquainted with the advantages and the theory of bevel gear drives, send for these Gleason Manuals:

20° Straight Bevel Gear System
Spiral Bevel Gear System
Zerol® Bevel Gear System

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

CIRCLE 140 READER SERVICE CARD

The Inside Story of a Finer Pump...

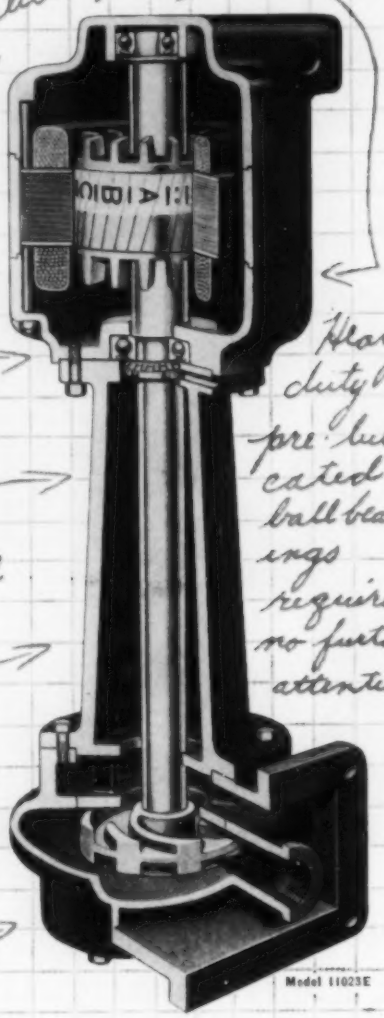
Electro-magnetically balanced rotor cuts vibration, prolongs bearing life.

No seal

NOTE—

Fewer parts to wear and repair.

No packing or priming needed



Heavy duty pre-lubricated ball bearings require no further attention.

Built Better to wear longer — Write for our complete catalog. There's a type and model to suit you.

THE Ruthman MACHINERY CO.

• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1818 Reading Road, Cincinnati, Ohio

converts to solenoid unit by replacement of pilot chamber with solenoid head, and vice versa. Either valve may also be converted from a normally open to normally closed unit by shifting pilot or solenoid chamber head 90°. Heavy-duty units operate on air pressure of 20 to 150 psi and are available in 12, 110, 220 and 440-v models. Thread sizes range from ¼ to 1 in. Valves are reported to have withstood continuous cycling for 10 million operations under normal conditions. **A Schrader's Son, Div of Scovill Mfg Co, 470 Vanderbilt Ave, Brooklyn, NY.**

Circle 25, Reader Service Card

Heavy-duty rod retainer . . .

has conically-shaped, notched center which exerts grip on shaft, seated or unseated. No notches or grooves are necessary. Fastener for ⅜-in.-dia unthreaded round rod requires 60-lb push-on force and has removal resistance of 1000 lb. Over-all dia is ¾ in.; over-all height, 0.085 in. Spring tempered steel retainer is available in plain steel, zinc peen and phosphate finishes. Typical applications are for retaining wheels on axles; retention of activating rods or cranks and for pivot-action assemblies. Free samples are offered. **Palnut Co, Glen Rd, Mountainside, NJ.**

Circle 26, Reader Service Card

Electromagnetic transducers . . .

for ac with emphasis on variable-reluctance type and linear variable-differential transformers are now in production. One differential transformer, now available, has a stroke longer than one-half housing length. Size has been reduced to ⅜ in. dia and unit is shielded from external fields. **Vinson Engineering & Sales Corp, 8044 Woodley Ave, Van Nuys, Calif.**

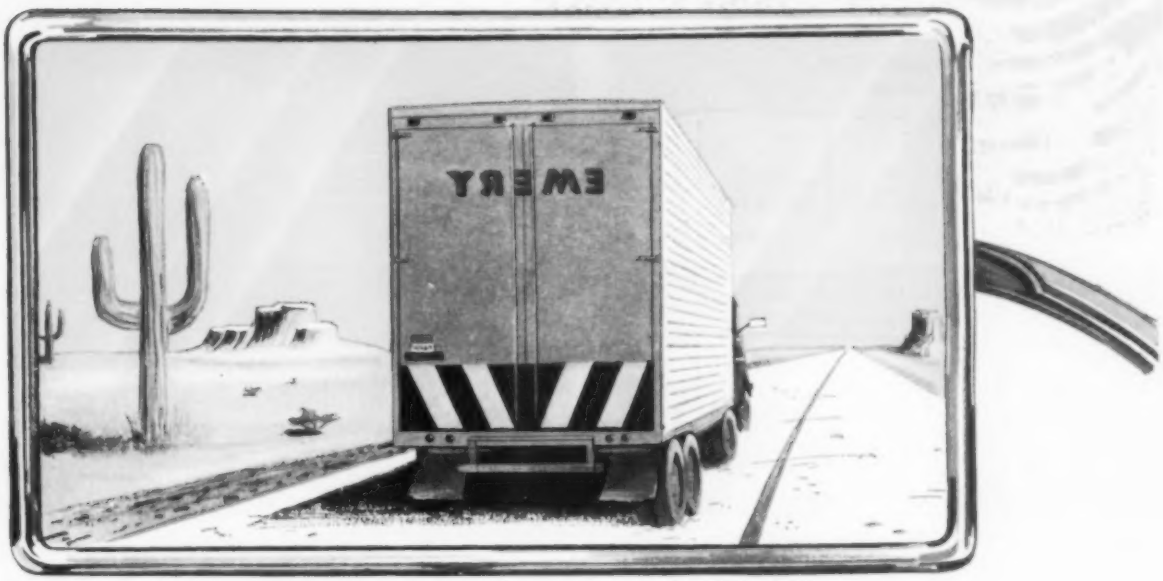
Circel 27, Reader Service Card

Gas-powered drive . . .

for remote timing and recording systems in 1-hr to 30-day periods. It has a gas or air consumption of 5 cfh at operating pressure of 5 psi. Mounts in any position. Timing-escapement spring is rewound every 5 sec to eliminate fluctuating torque, and clock accuracy is said not to be affected by wide fluctuations in supply pressure. **American Meter Co, 920 Payne Ave, Erie, Penn.**

Circle 28, Reader Service Card

RIGID URETHANE FOAM INSULATION
passes rugged "road test"!



In use under actual road conditions, rigid urethane foam insulation is rated excellent for all-around performance in refrigerated truck trailers!

It is currently proving its superiority as well in "reefer" cars, home appliances, and industrial, commercial and other refrigeration equipment.

Besides combining insulating efficiency with many practical plus values, urethane frequently costs less installed. Molded, sprayed or foamed in place or worked from slab stock, urethane foam saves production time and labor. Since it adds rigidity, lighter structural materials can be substituted in many applications

If you want to explore the use of urethane foam insulation, our application laboratory can give you valuable assistance. We produce NACCONATE® Diisocyanates, essential components in all urethane formulations.

Modular "sandwich" panels of rigid urethane foam, provide complete isolation for truck trailers, eliminating heat loss due to through-metal contacts.

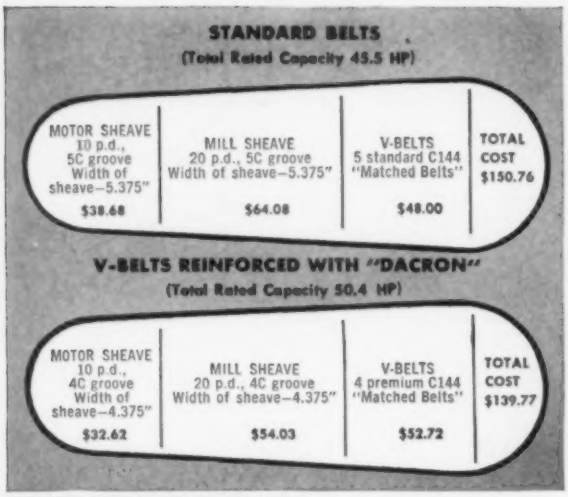
Lightweight urethane retains its high efficiency longer. It has low moisture pick-up, doesn't "pack down" and withstands 250°F. without deterioration. Modular construction facilitates repair and replacement.

NATIONAL ANILINE DIVISION
40 RECTOR STREET, NEW YORK 6, N. Y.
Atlanta Boston Charlotte Chattanooga Chicago Greensboro
Los Angeles Philadelphia Portland, Ore. Providence San Francisco

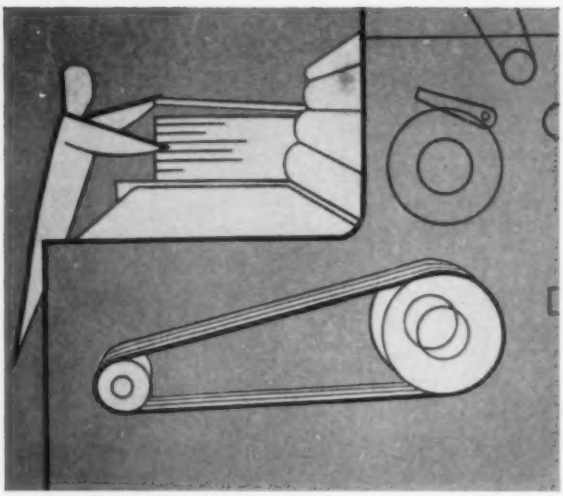
Allied Chemical

You can make significant cost savings with premium V-belts reinforced with DACRON

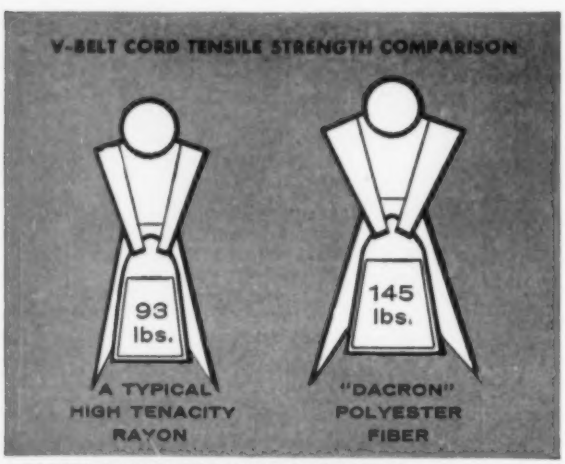
REG. U. S. PAT. OFF.


STANDARD BELTS
(Total Rated Capacity 45.5 HP)
MOTOR SHEAVE 10 p.d., 5C groove Width of sheave—5.375" $38.68
MILL SHEAVE 20 p.d., 5C groove Width of sheave—5.375" $64.08
V-BELTS 5 standard C144 "Matched Belts" $48.00
TOTAL COST $150.76
V-BELTS REINFORCED WITH "DACRON"
(Total Rated Capacity 50.4 HP)
MOTOR SHEAVE 10 p.d., 4C groove Width of sheave—4.375" $32.62
MILL SHEAVE 20 p.d., 4C groove Width of sheave—4.375" $54.03
V-BELTS 4 premium C144 "Matched Belts" $52.72
TOTAL COST $139.77

LOWER INITIAL DRIVE COST. Right from the start, premium V-belts reinforced with Du Pont "Dacron"* polyester fiber save you money! These belts offer greater horsepower capacity, a more compact drive that's easier to maintain.



"LASTED 52 TIMES LONGER than regular V-belts," reports a user of premium belts made with "Dacron". The rugged wearability of "Dacron" fiber extends belt life . . . permits continuous use without costly take-up for belt adjustment.



LESS MAINTENANCE, REDUCED INVENTORY. Even when compared with tough fibers of a high tenacity rayon V-belt cord, "Dacron" proves far stronger. In belts, this means less stretch, minimized matching problems and lowered inventory.

Premium V-belts reinforced with "Dacron" are ideal for high-impact or shock-load drives, yet last far longer than ordinary belts. In a typical installation, 5 premium belts reinforced with "Dacron" did the work of 7 conventional belts. Important economies resulted, too—through longer belt life and by reduction of the number of belts and sheaves.

In standard V-belts, too, the stability of "Dacron" practically eliminates matching problems . . . permits smaller belt inventories.

Check the cost-saving advantages of premium or standard V-belts reinforced with "Dacron" for the next drive you design or install. Du Pont makes the "Dacron" used by belt manufacturers in producing their finest-quality belts. E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Department, Wilmington 98, Delaware.

*"*Dacron" *is Du Pont's registered trademark for its polyester fiber.*

DU PONT
REG. U. S. PAT. OFF.

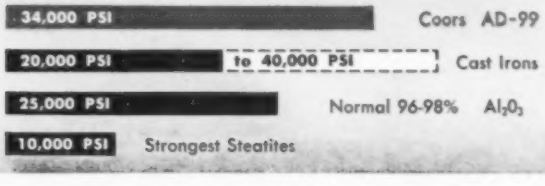
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

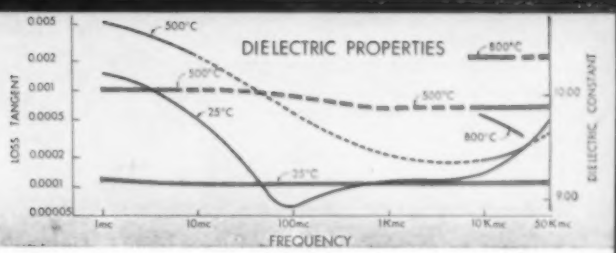
V-BELTS REINFORCED WITH "DACRON" transmit more horsepower . . . stand greater shock loads . . . give longer flex life . . . give greater opportunities for machine-design improvement.

Coors NEW AD-99 ALUMINA CERAMIC

AD-99 Ceramic Tube Envelope 10" dia x 8½"

TENSILE STRENGTH—ROOM TEMP.





SUPER DIELECTRIC — STRONG AS IRON 75% OF TENSILE STRENGTH AT 2000° F

Coors new AD-99 ceramic is nonporous 99.0% Al_2O_3 with the amazing tensile strength of 34,000 psi — as strong as cast iron. It has 30% greater strength than the best commercial high aluminas of 96% to 98% Al_2O_3. It is particularly superior to any ordinary metals in strength at high temperatures —retaining 75% of its tensile strength or 20,000 psi at 2000°F (1100°C).

Coors AD-99 is a superior dielectric material. At modern micro-wave frequencies, loss tangents are lower than those of plastics and all but one or two special ceramic materials—as reported by the Laboratory for Insulation Research, Massachusetts Institute of Technology. At room temperature, the loss tangent is 0.00006 ±0.00002 at 100 mc, less than 0.0001 at 300 mc, and 0.00052 at 50 Kmc.

These properties, combined with the excellent hardness and wear resistance of the alumina family, make this the most superior ceramic now available for commercial use. In addition, Coors AD-99 has complete, unequaled homogeneity made possible only through the use of the Coors isostatic process.*

Originally developed in Coors own laboratory especially for radome work, Coors AD-99 is now available on a commercial production basis for critical electronic and mechanical applications. We can make test parts for your developmental work at nominal costs. Production quantities can be supplied at prices only slightly higher than ordinary alumina ceramics.

Coors Porcelain Company operates under license for this patented process from Champion Spark Plug Company, Toledo, Ohio

COORS PORCELAIN COMPANY

Manufacturers of High Strength Alumina Ceramics

GOLDEN, COLORADO

COORS PORCELAIN CO., 688 9th St., Golden, Colo.

Please send me detailed bulletin on new Coors AD-99 Ceramic.

Name..... Title.....

Company.....

Address.....

City..... State.....

See our 12-page catalog in Sweet's Product Design File

Photo courtesy Electric Boat Division of General Dynamics Corp.

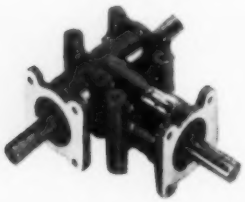
U.S.S. Skate, first production model atomic sub, carries a wealth of electric, hydraulic and mechanical equipment including numerous ANGLgear standardized 90° drives.

ANGLgear® specified for 90° drive aboard Skate

Military, industrial or consumer application—wherever you have a 90° power takeoff requirement in the ⅓ to 5 hp range, ANGLgear usually provides the simplest, most economical solution.

ANGLgear offers a number of advantages over V-belts or chains and sprockets. Featuring universal mounting, it is easier to design into your power transmission systems, easier to install. Incorporating positive bevel gear drive, it eliminates slippage and minimizes backlash problems. Completely enclosed, it presents no safety hazard. Permanently lubricated and equipped with antifriction bearings, it requires practically no maintenance. And ANGLgear invariably costs less than other types of right-angle drives.

You can specify ANGLgear in 16 different stock models, ⅓ to 5 hp, with 1:1 or 2:1 gearing and 2 or 3-way shafting. See our literature in Sweet's Product Design File or contact our local distributor.



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HILLSIDE 5, NEW JERSEY

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 97.

IRON POWDERS—Booklet 1014, 52 pp. Contains technical data on powders. Most information about property characteristics can be read from curves on a single set of ordinates. Lists specs for each powder and shows test shapes and calculations methods. Republic Steel Corp, 1441 Republic Bldg, Cleveland 1.

Circle 29, Reader Service Card

THERMOCOUPLE ASSEMBLIES—Catalog 1885, 36 pp. Specs, construction data and performance information on line of thermocouple assemblies and pressure sealing glands. Prices are included. Conax Corp, 2300 Walden Ave, Buffalo 25.

Circle 30, Reader Service Card

TRANSFORMERS—Catalog S-104, 32 pp. Covers electrical and physical specifications on line of over 750 transformers for industrial, communications, radio and TV applications. Includes output transformer charts, performance curves and special section on mounting styles. Indexing system has been added to 1959 edition. Chicago Standard Transformer Corp, 3501 Addison St, Chicago 18.

Circle 31, Reader Service Card

ROTARY PUMPS—Catalog 958B, 12 pp. Explains pumping principle, construction, specifications and application of series H, F, K, 3600 and T pumps and hydraulic pump-motors. Includes performance data. Roper Hydraulics Inc, Rockford, Ill.

Circle 32, Reader Service Card

CERAMIC INSULATED THERMOCOUPLES—Bulletin 3.8A, 8 pp. Describes thermocouples for use in industrial, missile aircraft, process and nuclear fields. Includes specs, standard designs, typical connectors, junctions and terminations and typical applications. Illustrated. Aero Research Instrument Co, 315 N. Aberdeen St, Chicago 7.

Circle 33, Reader Service Card

SMALL, COLD-DRAWN TUBING—Bulletin 41, 12 pp. Selection and application guide gives form, characteristics and uses of 63 standard and 26 special materials cold-drawn into small tubing. Describes special types of tubing for special applications. Standard tubing tolerances, lengths, straightness and tempers are listed. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.

Circle 34, Reader Service Card

STEEL TUBING—Catalog CS-59, 8 pp. Information on fabricated and forged steel tubing, special shapes, tolerances and size ranges. Describes seamless and resistance-welded steel tubing in mechanical, airframe and pressure grades. Ohio Seamless Tube Div, Copperweld Steel Co, Shelby, Ohio.

Circle 35, Reader Service Card

SPECIAL-PURPOSE ALLOYS FOR WELDED TUBING—Bulletin TD-125, 8 pp. Covers sizes, gages, finishes, chemical composition, mechanical and physical properties of high-temperature, low-expansion and high-permeability alloys for tubing and pipe. Data includes fabrication characteristics, corrosion and oxidation resistance information and typical applications. Alloy Tube Div, Carpenter Steel Co, Union, NJ.

Circle 36, Reader Service Card

SUPERALLOY AND REACTIVE METAL TUBING—Handbook and wall chart, 44 pp. Contains data on neutron transparency, heat treatment, corrosion resistance, chemical and physical analysis, mechanical properties, size and application of tubing and pipe. As a supplement, wall chart compares corrosion effects of 44 common corrosive solutions upon zirconium, titanium, tantalum, Hastelloy C, and stainless steel 316. Damascus Tube Co., Greenville, Penna.

Circle 37, Reader Service Card

SMALL ALLOY TUBING—Brochure, 12 pp. Discusses drawing, annealing, finishing and testing. Covers materials, properties and typical applications of tubing, specification of temper, tolerances of straight and coiled tubing. Alloys, tolerances, wall thicknesses and lengths are listed for all sizes. Precision Tube Co, Dept 12, North Wales, Penna.

Circle 38, Reader Service Card

SMALL PANEL INSTRUMENTS—Bulletin GEA-6678, 6 pp. Stresses appearance, readability and operation of new design. Cutaway views show features. Includes ratings, dimensions, price, size and panel drilling plans. General Electric Co, Schenectady 5.

Circle 39, Reader Service Card

COMPENSATED CONVEYOR BELT—Bulletin M302, 12 pp. Drawings are

(Continued on page 90)

This FLOW REGULATOR is simpler in design and lower in cost

This unit exceeds MIL-V-8566 specifications in both regulation accuracy and pressure drop, thus confirming the tradition, *You can expect more from Vinson.*

OPERATION

PRESSURE	PROOF	BURST
3000 psi	4500 psi	7500 psi

Media
Hydraulic fluids & fuels. Available in stainless steel for corrosive liquids.

AMBIENT RANGE
-65° to 275° F.

OTHER CHARACTERISTICS
In stainless steel body, up to 600° F. Contains no seals; can replace restrictor valves; unaffected by back pressure. Sizes: ½", ⅜" and ⅝" have interchangeable parts. Available in ⅛" up to ¾"; larger tube sizes to order. Any type port available.

Externally adjustable types available for laboratory use and system evaluation. Internal elements available for cartridge evaluation.

WHAT'S YOUR FLOW PROBLEM? Your inquiry will receive an immediate reply from engineers experienced in the specialized problems of flow control.

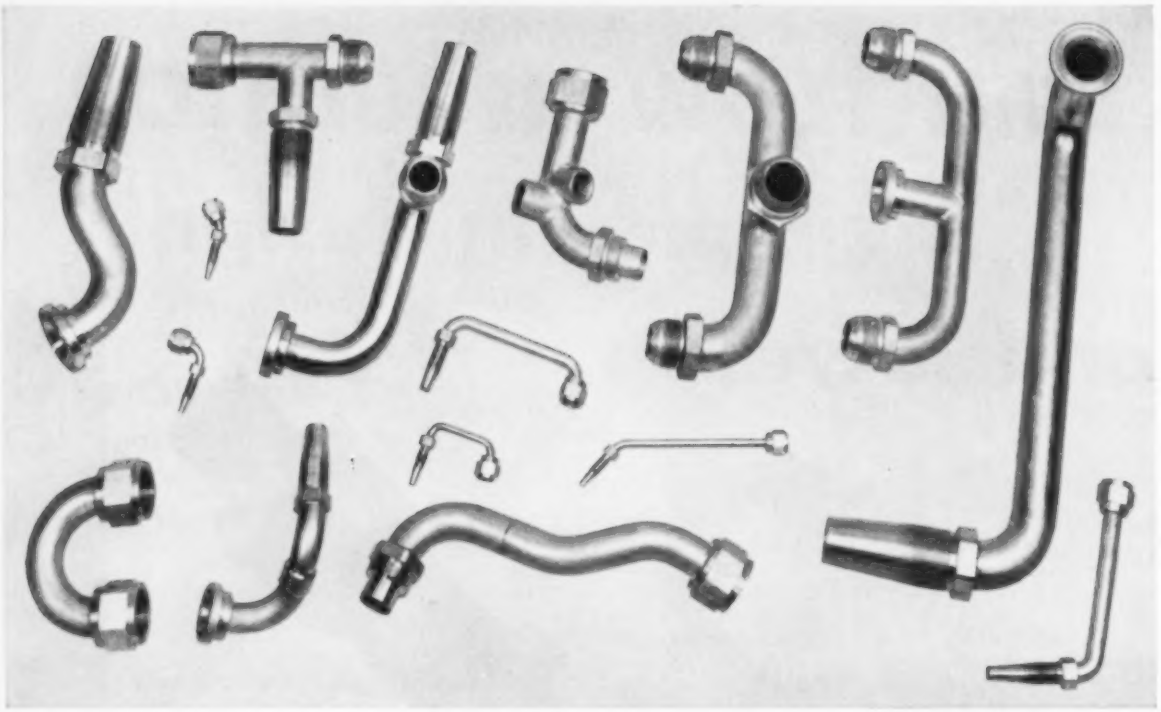
Expect more from **VINSON**

PRESSURE REGULATORS
RESERVOIRS • ACCUMULATORS

VALVES: RELIEF • SHUTTLE • RESTRICTOR • UNLOADER • SNIFFLE • SOLENOID • BUTTERFLY

TELEPHONES: ST 3-2750 — ST 3-2576

8044 WOODLEY, VAN NUYS, CALIFORNIA



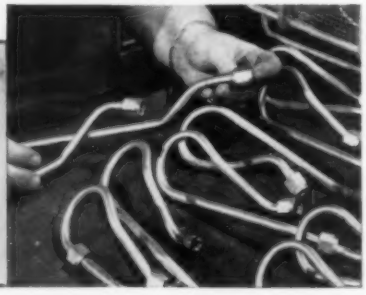
Solve Fluid System Design Problems with Aeroquip Precision Tubing . . . Formed to Your Specifications

Fluid systems requiring special formed tubing can be designed with Aeroquip precision tubing fabricated to your exact specifications. With over 10 years' experience producing high quality aircraft tubing, Aeroquip has the engineering skill and test equipment to make sound design recommendations for all types of industrial fluid systems. Extensive manufacturing facilities assure volume production of any tubing configuration, in a wide range of materials, sizes and fitting connections.

Submit your fluid line problem to our sales engineering department and mail the coupon below for our precision tube forming Catalog No. 500.

ABOVE—Fittings for this steel tube configuration are being arc welded with an inert gas shield to produce a sound, more uniform weld. Five different welding or brazing processes for tubing are available at Aeroquip.

BELOW—Volume production of this 5-bend tubing configuration was made possible by the development of unique tube-forming equipment by Aeroquip engineers.



Aeroquip

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AEROQUIP CORPORATION, JACKSON, MICHIGAN

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AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

INFORMATIVE CATALOG AVAILABLE PE-10

AEROQUIP CORPORATION, JACKSON, MICHIGAN

Please send me a copy of Catalog No. 500 on Aeroquip Precision Tube Forming facilities

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

News about R&A SINCE 1913 **Adhesives**

FOR ALL METALS AND ALL PLASTICS

New foam (urethane or latex) adhesive travels farther–bonds faster

TECHNICAL DATA ON

Bond*master* R275

A strong, quick-drying, exceptionally fast-grabbing, "non-dimpling" foam-splicing adhesive. Incorporates new synthetic polymer which permits swift application of minimum glue line thicknesses without "bare spot" hazards. Resultant seams are softer than has been possible up to now, yet the bonds are stronger than the foam or sponge.

This ability to apply such extremely thin glue lines also results in: greater yield-per-gallon (thereby lowering materials costs); faster "grab" (leading to increased production speed); avoidance of "dimpling" (which represents the most serious hazard in foam cushion manufacture).

Used for soft-seam bonding all foams to themselves and *to each other* . . . and for cementing fillers, boxing, and crowning.

SPECIFICATIONS

VISCOSITY: 600-1,000 cps; COLOR: clear, pale yellowish; BASE: synthetic elastomer; SOLVENT (dilution or cleanup): toluol; TACK LIFE: up to 15 minutes; WEIGHT PER GALLON: approx. 6.8 lbs; SOLIDS: 14-16% by weight; ODOR: non-residual; STORAGE: 1 year.

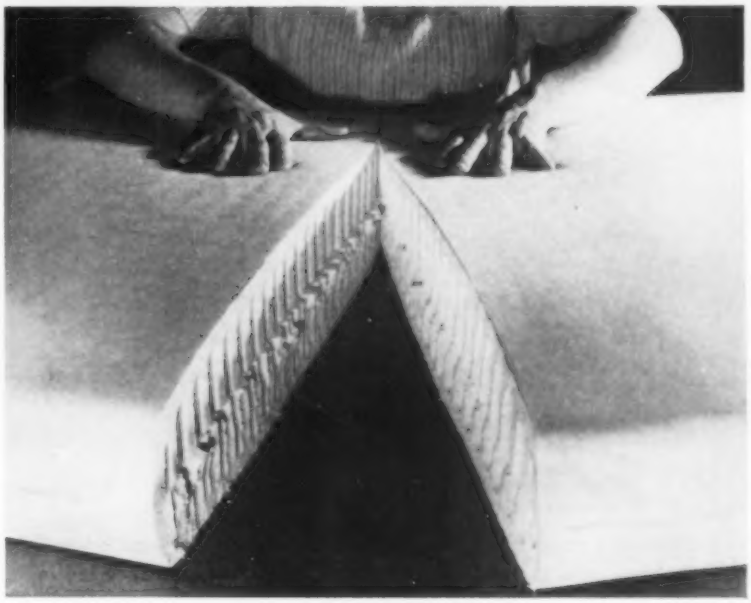
APPLICATION

Using brush, spray gun, or roller, apply thin coat to each surface to be bonded. Air dry briefly and gently press surfaces together. A firm bond results at once.

R&A SINCE 1913

RUBBER & ASBESTOS CORPORATION

235 BELLEVILLE AVENUE
BLOOMFIELD, NEW JERSEY



Either or both of the slabs shown above could just as well have been polyurethane foam as far as our unique new BONDMASTER R275 is concerned. You'd enjoy the same:

- Material-saving, greater adhesive coverage
- Labor-saving, controlled spreadability
- Time-saving, swifter "grab"
- Thinner glue lines than ever before possible
- Softer seams than ever before possible
- "Foam-tearing", stronger bonds

. . . than with any other non-dimpling adhesive you've ever before tested for either rubber or urethane foams. This new formulation handles *both* foams with equal ease and effectiveness.

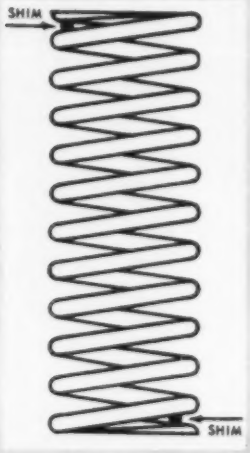
We can speak with authority here, since this new BONDMASTER R275 is rapidly supplanting our R225 – which we developed in 1947 as the first practical rapid-tack-loss, one-part, fast-grab, soft-seam adhesive for foam rubber and which has maintained its position as the "industry leader" until now.

If your product involves the bonding of flexible foams to themselves or to each other, it will pay you to investigate the time-, labor-, and cost-savings that BONDMASTER R275 can bring to your production. We'll be glad to send a sample if you mail your request on your business letterhead.

it's the shim that counts in

CHATILLON COMPRESSION SPRINGS

Available in practically all sizes and capacities



Chatillon's compression springs with calibrated shims—an original Chatillon development—perform so accurately, they are specified in the precision instruments of leading manufacturers: e.g.: General Electric (ordnance equipment), Bendix (pressure transmitters), Chandler-Evans (aircraft carburetors). Shims brazed on the end coils of this spring maintain constant number of active coils during compression, thereby insuring constant rate. Straight line relationship between load and deflection is considerably improved. This great increase in accuracy, costs no more! Chatillon compression springs are available in Iso-Elastic* (Chatillon's own temperature-compensated alloy) or other spring alloys. Chatillon also manufactures Spiral, Torsion and Form Springs in Iso-Elastic and conventional alloys.

Have Chatillon's Spring Division show you how easily you may improve the accuracy of your instruments. Write for engineering bulletins.

*U.S.A. Pat. No. 2174171

JOHN CHATILLON & SONS

85 CLIFF STREET, NEW YORK 38, N.Y.

Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

used to describe features and pages are arranged to represent an actual cross-section of belt. Manhattan Rubber Div, Raybestos-Manhattan Inc, Passaic, NJ.

Circle 40, Reader Service Card

REMOTELY OPERATED RELIEF VALVES—Data sheet 1.33a, 1 p. Specifications, capacity and dimensional information on remotely operated, pilot-type relief valves for handling oil to 3000 psi. Fluid Controls Inc, 1284 N Center St, Mentor, Ohio.

Circle 41, Reader Service Card

CENTRALIZED POWER LUBRICATION SYSTEMS—Bulletin 812, 4 pp. Describes and illustrates pumping units for low and high-pressure applications, lubricant injectors used with pumps and controls and accessories for systems. Specs and dimensions are given. Lincoln Engineering Co, 5737 Natural Bridge Ave, St. Louis 20.

Circle 42, Reader Service Card

METAL BALLS—Catalog 458, 4 pp. Discusses and defines standards applying to balls. Gives materials, sizes, sphericity, tolerance specifications and packaging data in tabular form. Strom Steel Ball Co, Erwin, Tenn.

Circle 43, Reader Service Card

HEAT-, CORROSION- AND OXIDATION-RESISTANT ALLOY – Bulletin 105 in file folder, 4 pp. Physical and mechanical properties of a nickel-chromium-iron composition alloy with high resistance to heat, corrosion and oxidation. Lists standard stock sizes of cold-drawn wire and hot-rolled rods, flats and squares. Hoskins Mfg Co, 4445 Lawton Ave, Detroit 8.

Circle 44, Reader Service Card

MICROMINIATURE RELAYS – Bulletins 700 and 780, 2 pp each. Data on current-sensitive and voltage-sensitive single-pole and double-pole units, particularly suited for printed circuits. Specs, typical adjustment schedule, dimensional and circuit diagrams, header and mounting variations are included. Electronics Div, Iron Fireman Mfg Co, 2838 E 9th Ave, Portland 2, Ore.

Circle 45, Reader Service Card

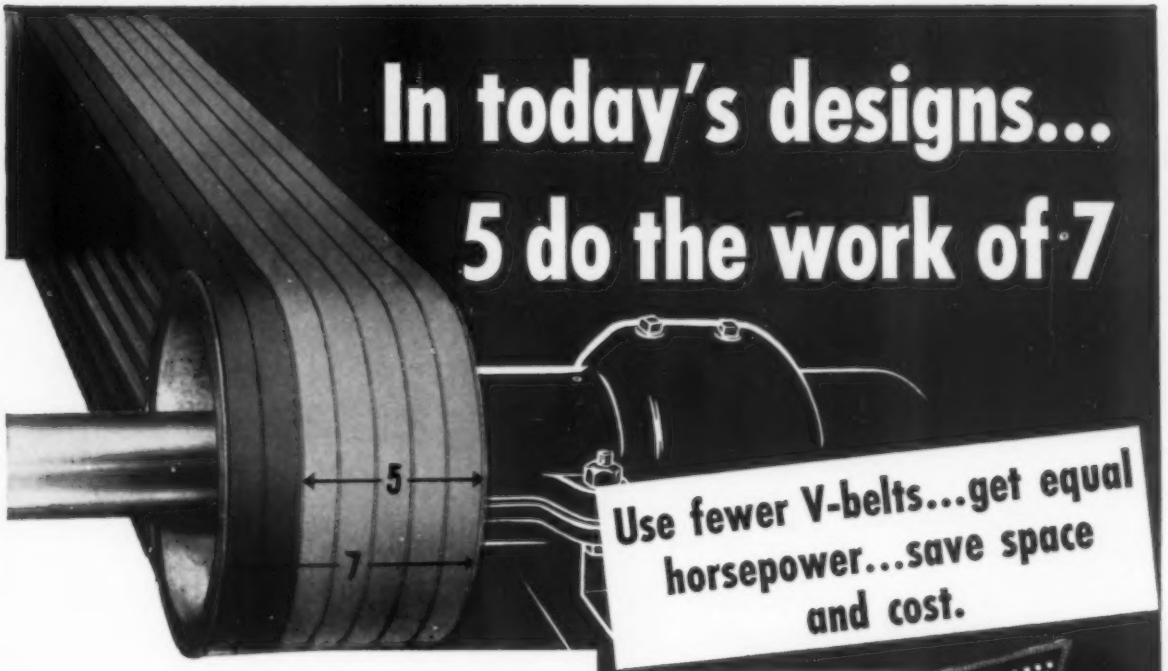
SERVO-MOUNTING POTENTIOMETERS—Data sheet 1362, 4 pp. Includes electrical, mechanical and environmental specs on all-metal 1 1/8-in.-dia potentiometers. Gives coil data, power input chart and dimensional drawings. Helipot Div, Beckman Instruments, Inc, Fullerton, Calif.

Circle 46, Reader Service Card

STAINLESS STEEL THERMOMETERS—Bulletin 13E, 8 pp. Lists specs

(Continued on page 95)

In today's designs... 5 do the work of 7



Use fewer V-belts...get equal horsepower...save space and cost.

With 40% more horsepower, 5 Gates Super Vulco Ropes do the work of 7 standard V-belts... improve drive design. That's why—

A Super Vulco Rope Drive delivers more horsepower per dollar invested than any standard V-belt drive.

Comprehensive drive data is available to you quickly. Just call your nearby Gates distributor for a Gates V-Belt specialist. Stocks carried in industrial centers throughout the world.

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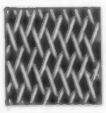
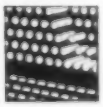
No other V-Belt has ALL these advantages



1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.



3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads... reduce number of belts required... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

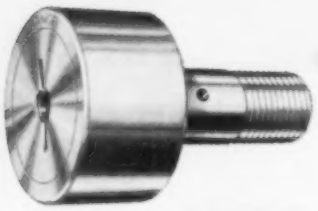
5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 331

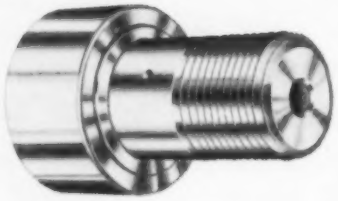
Gates Super V VULCO ROPE Drives

Why ORANGE bearings assure smooth, rugged service in Cam Action—Support—or Track Applications

ORANGE
CAM FOLLOWERS



TYPE S
Standard
Stud

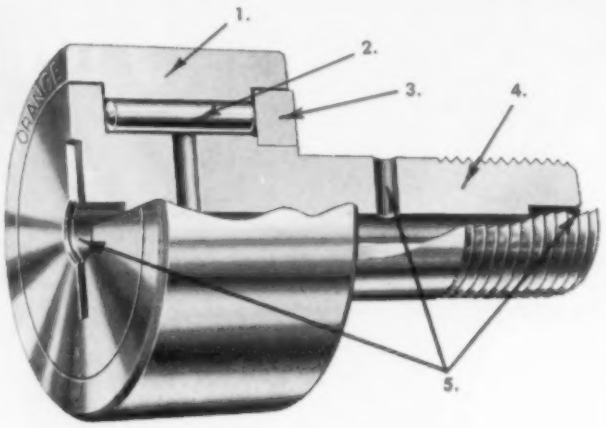


TYPE H
Heavy Duty
Stud

Heavy stud is available to afford greater shear resistance of the stem where severe operating conditions exist.

•

Orange Cam Followers are available in 22 standard sizes from ½" to 4" O.D. Chrome, Cadmium or Black Oxide finishes can be supplied. May be provided with seals where conditions require.



1. **Heavy-sectioned outer race** is made of thru-hardened, precision-ground, high quality bearing steel.

2. **Small diameter rolls** are made of high grade bearing steel, electronically gauged for uniformity of size.

3. **Case-hardened End Plate** permits the use of effective press fit for retention.

4. **Induction-hardened Stud** assures maximum hardness of the roller track, with core toughness to withstand high shock loads. Slotted end for convenient screw driver mounting.

5. **Selective Lubrication** for design flexibility. Drilled for drive type fitting. Closing plugs also furnished.

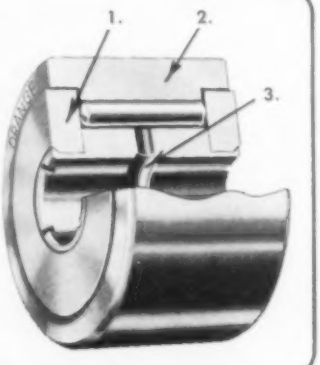
ORANGE
CAM YOKE ROLLERS

Ideal for yoke mounting in all types of machinery involving cam action, or control of machine elements requiring guide or support rollers. Available in 18 sizes from ¾" to 4" O.D. and can be furnished with Chrome, Cadmium or Black Oxide finishes.

1. **Staked End Plate.** The inner race is zone-hardened on the roller path for wear-resistance, while the ends remain more ductile to permit substantial staking for self-retention. Eliminates displacement caused by flimsy rings or insufficient deformation of thru-hardened inner races.

2. **Heavy outer race** thru-hardened to carry heavy loads.

3. **Ample lubrication** through center channel.



Write for 40-page Engineering Manual giving full details on Orange Cam Followers and Yoke Rollers, plus complete line of Orange Roller Bearings.

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551 Main Street, Orange, N. J.

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Journal Roller Bearings — Thrust Roller Bearings
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Shoulder Drive

Style G — No. 505
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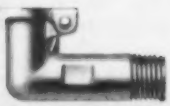
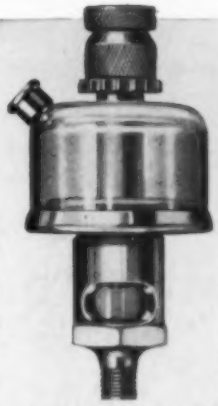
Style GB — No. 527
Ball Valve



Style L — No. 1204
Brass Elbow (Threaded)

SIGHT GRAVITY FEED OILERS

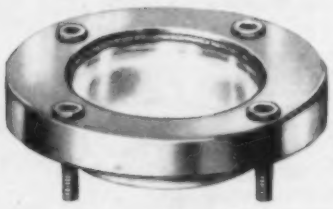


Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

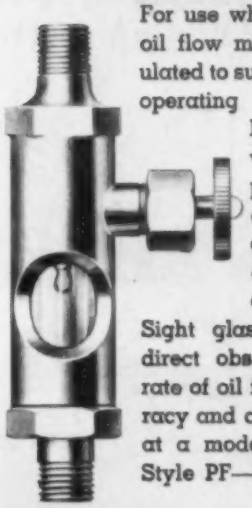
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

GEAR CASE GAUGES



Screw mounted, to set flush. Glass port is backed with white enameled reflector, to make oil level (in gear case or transmission) readily visible, even in dim light. Style CW — No. 4032.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

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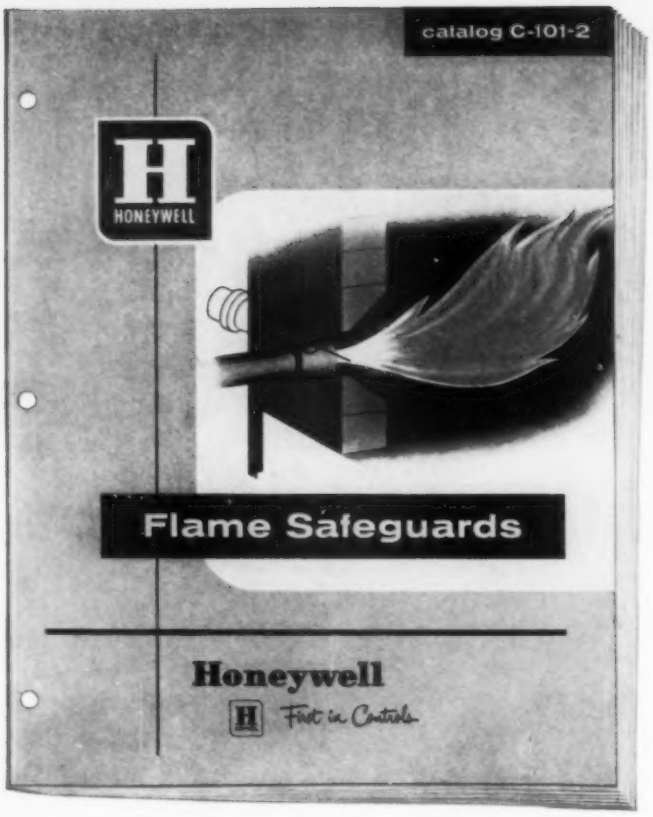
Honeywell Flame Safeguard Catalog...

...describes and illustrates all components—complete systems—for protecting plant, personnel, and product in industrial gas and oil-burning installations.



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Honeywell Catalog C-101-2 tells you about new, up-to-date flame safeguard equipment for every conceivable type of single and multi-burner installation. It includes specifications and illustrations of every unit, and explains how each operates. Also included is useful information about auxiliary equipment—switches, valves, relays, timers, etc. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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First in Controls

and prices for more than 100 angle-form, straight-form and special-purpose thermometers. With photos, cutaway and dimensional drawings. W C Dillon & Co Inc, 14620 Keswick St, Van Nuys, Calif.

Circle 47, Reader Service Card

STEEL CASTINGS—Folders, 6 and 4 pp. Describes line of standard and special steel castings, illustrating various parts. Chemical analyses, physical properties and comparable specs of all production cast steels are shown in tabular form. Basic steels and products are discussed. Farrell-Cheek Steel Co, Sandusky, Ohio.

Circle 48, Reader Service Card

ELECTRICAL CONTROL CABLES—Bulletin CC-10, 4 pp. Construction and application data. Lists sizes and specs. Triangle Conduit & Cable Co Inc, New Brunswick, NJ.

Circle 49, Reader Service Card

PNEUMATIC VIBRATION ISOLATION SYSTEMS—Brochure, 4 pp. Discusses design of servo-controlled pneumatic vibration isolators and describes operation. Includes photo of longitudinal actuator and graph of transmissibility. Walter Kidde & Co Inc, Belleville 9, NJ.

Circle 50, Reader Service Card

AIRCRAFT AND MISSILE ACCESSORIES—Bulletin F 5910-1, 4 pp. Condensed catalog of basic air valves and actuators, temperature-control and positioning systems, and specialized electrical test equipment. Also notes development, testing and production facilities. Barber-Colman Co, 1400 Rock St, Rockford, Ill.

Circle 51, Reader Service Card

DIALS, PANELS, NAMEPLATES—Idea file, 6 pp. Describes shapes, sizes, materials, finishes and markings available in dials; types, styles, finishes, colors and mounting methods offered in nameplates; design, lighting and fabricating process for panels. US Radium Corp, Morristown, NJ.

Circle 52, Reader Service Card

MAGNETIC FRICTION CLUTCHES AND BRAKES—Bulletin RSF-1, 8 pp. Discusses operation, performance, construction, controls and specifications of flange-mounted clutch, bearing-mounted clutch and replaceable-face brake. With photos, cutaway illustrations, dimensional drawings and circuit diagrams. Dynamic Div, Eaton Mfg Co, Kenosha, Wis.

Circle 53, Reader Service Card

ELECTRONIC GO-NO-GO GAGE—Bulletin, 4 pp. Describes series 620 instruments, which are designed for frequency stability and comparison checks, motor speed control, pressure and flow control,

(Continued on page 97)

FLAMEMASTIC
INSULATION COATING
PROTECTS
ORDINARY METALS TO
4500° F!
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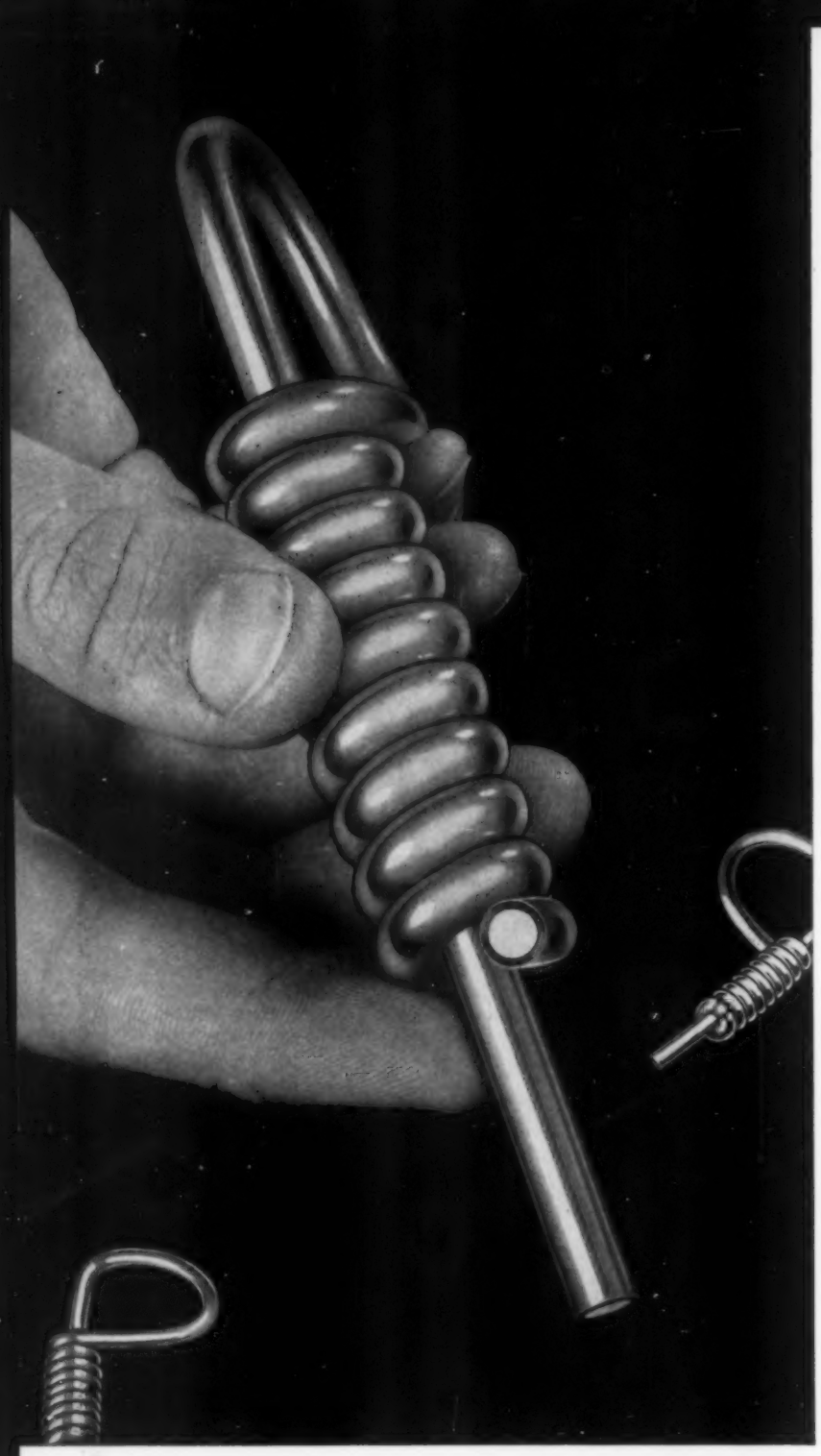

Get as "rough" as you want with

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Even the most severe usages known cause no measurable deterioration of the copper coating on Copperply Wire. This is both field and laboratory proved!

Shown here, for example, are standard wrap test specimens. Despite this extreme bending, neither microscopic examination nor ferroxyl testing show any hint of coating fracture or porosity.

You may well ask why. For one thing, the National-Standard electroplating process provides a homogeneous, high density coating . . . and, regardless of wire size, the maximum variation in copper thickness is less than 1% of diameter!

Copperply wire, offering you unmatched uniformity and service life, is available in the popular ASTM 30% and 40% conductivity grades. In addition, the precise control of the process permits the deposition of lighter coatings with the same degree of concentricity for varied electrical, electronic and mechanical applications where less copper is required. Copperply wire can be custom-produced to the copper thickness to give you the exact degree of conductivity or corrosion resistance required.

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NATIONAL-STANDARD, Niles, Mich.; *tire wire, stainless, music spring and plated wires, flat and tubular braid and wire cord.*
WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires, high and low carbon specialties.* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth.*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment.* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels.*
CROSS PERFORATED METALS, Carbondale, Pa.; *industrial, commercial and decorative perforated metals.*

CIRCLE 153 READER SERVICE CARD

material flow control and other limiting situations occurring between 1 and 40,000 times per sec. Gives features, specs, operational data, typical applications, basic design information and construction. Computer Measurements Corp, 5528 Vineland Ave, N Hollywood, Calif.

Circle 54, Reader Service Card

PLASTIC CORE BELTING—Bulletin 801, 4 pp. Describes belt characteristics. Includes tables (hp capacity, min pulley diameters, correction factor for arc of contact and belt life) to guide specification of proper belting. Graton & Knight Co Inc, 356 Franklin St, Worcester 4, Mass.

Circle 55, Reader Service Card

NICKEL ALLOY COATING—Bulletin 258, 12 pp. Describes process by which coating is chemically deposited. Includes chemical analysis, property data and application information. General American Transportation Corp, 135 S La Salle St, Chicago 90.

Circle 56, Reader Service Card

TOOL STEELS—Comparison chart. Lists 43 brand names on carbon, alloy and high-speed tool steels, AISI type. Chart folds over. Covers high-speed, hot-work, tool and die, shock and special purpose, plastic mold, carbon and carbon vanadium tool steels. Vulcan-Kidd Steel Div, H K Porter Co Inc, Aliquippa, Penna.

Circle 57, Reader Service Card

MINIATURE RHEOSTAT—Bulletin 157, 2 pp. Model E rheostat, capable of dissipating 12½ w, is described. Includes related operating and dimensional data, and standard modifications. Ohmite Mfg Co, 3686 Howard St, Skokie, Ill.

Circle 58, Reader Service Card

CABLE CALIPER—Measures cylindrical objects to 2 in. dia; indicates jacket sizes. Free. Zippertubing Co, 752 S San Pedro St, Los Angeles 14.

Circle 59, Reader Service Card

Letterhead Requests Only

Manufacturer who published following literature asks that requests for copies be made on company letterheads.

PLASTICS—Reference manual, 132 pp. Nontechnical book on plastics, now in its 11th edition. Discusses how plastics were developed, how they are used, and why. Explains physical properties, types of molding, elements of part design, designing pitfalls, machining and inserts. Tables and data on most plastic materials are included. Available only to readers in the US and territories. Boonton Molding Co, 326 Myrtle Ave, Boonton, NJ.

MEET THESE 4 CHALLENGES

NEW INCONEL-X
Sylphon Bellows

Searing heat. Bitter cold. Extreme pressure. Severe corrodents. Jarring shock and vibration. Now you can successfully meet these challenges in aircraft, and missile applications. New Inconel and Inconel-X bellows, perfected by Fulton Sylphon, give you important advantages in designing controls, valves, joints, ducts and other components.

These nickel-chromium alloy bellows possess exceptional strength and resistance to corrosion at high temperatures. Age-hardening Inconel-X offers superior stability and "hysteresis" factor. Durability tests indicate three times the life expectancy of similar bellows made from stainless steel. Can be made in sizes from 15/32" to 12" O.D. . . . single or multi-ply construction . . . with *complete* assembly if desired. Engineering assistance for any specific application available on request.

*Depending on application.

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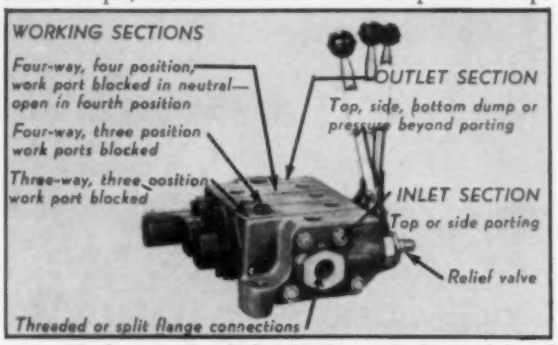
DESIGNER'S CHECK LIST

VALVES — CONTROL OIL HYDRAULIC POWER

flow performance as much as 20 gpm (05 series), 30 gpm (07 series) and 55 gpm (10 series) with back pressure ratings under 100 psi, non-constricted flow reduces pressure drop.

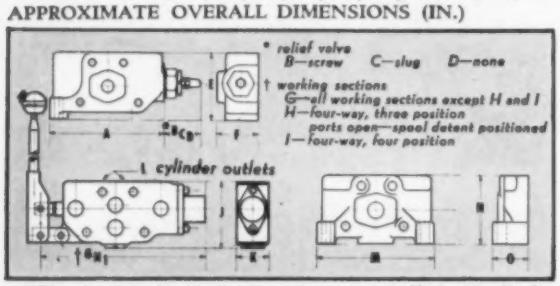

WORKING SECTIONS
Four-way, four position, work port blocked in neutral—open in fourth position
Four-way, three position work ports blocked
Three-way, three position work port blocked
OUTLET SECTION
Top, side, bottom dump or pressure beyond porting
INLET SECTION
Top or side porting
Relief valve
Threaded or split flange connections

"Performance Rated" directional control valve consisting of inlet, three working and outlet sections assembled into leakproof unit. Any combination of working sections can be assembled in any sequence into a single space saving unit.

INTERNAL PRESSURE DROP (PSI)
in one four-way, three position working section when circuit is loaded — work ports pressurized.

	FLOW (GPM)										
	5	10	15	20	25	30	35	40	45	50	55
05 SERIES	5.4	21.6	48.5	86.2							
07 SERIES			22.5	40.0	62.5	90.0					
10 SERIES							37.6	49.2	62.3	77.0	93.0

APPROXIMATE OVERALL DIMENSIONS (IN.)

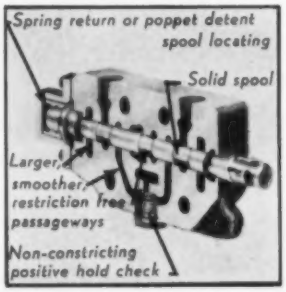

* relief valve B—screw C—slug D—none
† working sections G—all working sections except H and I H—four-way, three position ports open—spool detent positioned I—four-way, four position
‡ cylinder outlets

SIZE	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
½"	7	2¼	1	⅛	4	1⅛	2½	10	12 1/16	13	3⅞	2	½	7¼	4 1/16	2¼
¾"	8	2¼	1	⅛	4	⅞	2¾	11 3/16	13 ⅜	14 3/16	4¾	2½	¾	8¼	4	⅞	2⅝
1"	10	3	1¼	⅛	6	½	3½	14	17 ¼	17 ¾	6¼	3	1	10½	6	½	3¼

OPERATING PRESSURE 2000 PSI
O-rings seal against leakage—dense hi-tensile castings absorb stress without distorting.

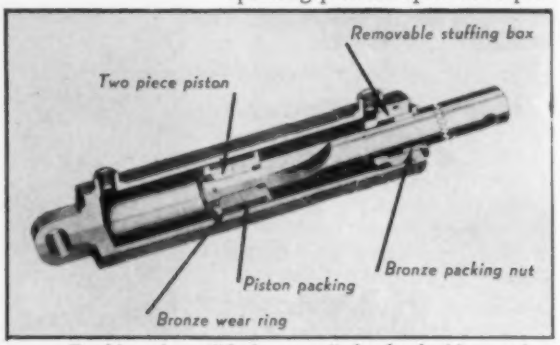
NO LOAD DROP
Positive hold check built into each working section prevents load drop or sag.

OVERLOAD RELIEF—PRESSURE CONTROL
Sensitive cartridge type pressure relief provides safety bypass protection against overload of hydraulic system


Spring return or poppet detent spool locating
Solid spool
Larger, smoother, restriction free passageways
Non-constricting positive hold check

CYLINDERS — UTILIZE OIL HYDRAULIC POWER

single acting, double acting, telescopic
capacity up to 25 tons—stroke up to 45 inches
operating pressure up to 1500 psi.



Double acting solid plunger cylinder fitted with two piece piston. Disassembly for easy inspection and replacement of piston or stuffing box packings is a simple field operation. Note there is no metal to metal contact between piston and cylinder.

DOUBLE ACTING

ROD. DIAMETER		1	1¼	1¼	1½	1½	2	2	2½	2½
CYLINDER O.D.		2½	2⅞	3	3⅞	4⅞	5⅞	6⅞	8	9¼
DISPLACEMENT	PUSH	.014	.017	.021	.036	.061	.094	.133	.179	.242
	PULL	.010	.012	.016	.028	.054	.080	.119	.158	.220
EFFECTIVE AREA	PUSH	3.1	4.0	4.9	8.3	14.2	21.6	30.7	41.3	55.9
	PULL	2.4	2.7	3.7	6.5	12.4	18.5	27.5	36.3	50.9

SINGLE ACTING

PLUNGER DIA.	1	1½	1¾	2	2½	2¾	3¾	4¾	5¾	6¾	7⅞
CYLINDER O.D.	1⅞	2⅜	2⅝	2⅞	3½	3⅞	4⅞	5⅞	6⅞	8	9¼
DISPL'CM'T	.003	.008	.010	.014	.021	.026	.048	.077	.112	.155	.210
EFF. AREA	0.8	1.8	2.4	3.1	4.9	5.9	11.0	17 7	26.0	35.8	48.7

TELESCOPIC

SLEEVE DIAMETER

SLEEVE NO.	CYLINDER O.D. 4⅞	5⅞	6⅞	8	9¼
1ST	3¾	4¾	5¾	6¾	7⅞
2ND	2¾	3¾	4¾	5¾	6¾
3RD		2¾	3¾	4¾	5¾
4TH			2¾	3¾	4¾
5TH				2¾	3¾

DISPLACEMENT

SLEEVE NO.	CYLINDER O.D. 4⅞	5⅞	6⅞	8	9¼
1ST					
2ND	.037	.062	.095	.133	.183
3RD		.050	.079	.115	.159
4TH			.066	.098	.139
5TH				.083	.121

Figures in tables shown in units as follows: diameter—inches, area—square inches capacity—pounds, pressure—lbs. per sq. in. displacement—gallons per inch of stroke

EFFECTIVE AREAS OF SLEEVES

SLEEVE DIAMETER	2¾	3¾	4¾	5¾	6¾	7⅞
EFFECTIVE AREA	5.9	11.0	17.7	26.0	35.8	48.7

Cylinder capacity, neglecting friction loss, can be approximated by multiplying rod, plunger or sleeve effective area by operating pressure.

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Dept. G-44, Youngstown, Ohio

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Low pressure housing

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Whether it's resistance to high temperature, oil or abrasion—or flexibility at low temperature or room temperature, there's a Reevecote designed to do your job.

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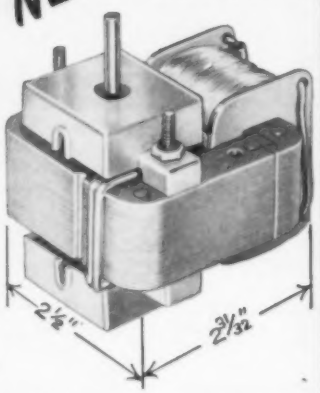
NEW! 2-POLE, SHADED-POLE MOTOR 1/550 HP to 1/50 HP



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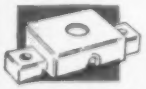

DIE-CAST BEARING BRACKET This new "H" Motor design includes a rugged die-cast bearing bracket that insures permanent precision alignment and adds to the over-all durability.

Write today for catalog sheet and quantity-price quotations.

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DESIGN ABSTRACTS

Understanding Automatic Control

Part I of this 2-part article discusses meaning of mechanized information handling, system concept, process of converting ideas to signals suitable for automatic control equipment. Part II will describe combinations of digital-analog controls, computers.

"How to Understand Automatic Control," G H and P S Amber, American Machinist, Sept 22, '58, 330 W 42nd St, New York 36.

ASME-ASLE Lubrication Conference*, Los Angeles, Oct 13-15

Mechanism of Gear Lubrication

Scoring and wear of gears are evaluated as functions of operating variables, gear geometry, construction and lubricant properties. Results of experiments with extreme pressure lubricants are given, showing distribution and thickness of films and rates of attrition. A mechanism of gear lubrication is postulated and discussed.

"On the Mechanism of Gear Lubrication," V N Borsoff, Shell Development Co, Paper 58-LUB-4.

Three-lobe Bearing

Analytical solution of three-lobe bearings is offered based on solution of finite Reynolds equation. Expressions for eccentricity, lubricant flow, power loss and spring constant are given for a range of 4D ratios and ellipticities. Charts and equations for setting design requirements and calculating performance are included.

"Analysis and Characteristics of Three-lobe Bearing," O. Pinkus, General Electric Co, Paper 58-LUB-2.

Friction and Wear of Metals to 1000 C

Sliding experiments with zinc, copper, titanium and 1020 steel are reported.

"Friction and Wear of Metals to 1000 C," Kingsbury and Rabinowicz, MIT, Paper 58-LUB-6.

Dry Adhesive Wear

Sliding-motion experiments on various steels and brass under unlubricated conditions are discussed in terms of simple wear theory advanced by Archard.

Abstracted from "An Investigation of Dry Adhesive Wear," R P Steijn, E I duPont de Nemours & Co, Paper 58-LUB-8.

**Copies of these papers obtainable from ASME, 29 W 39th St, New York 18.*

Rust Preventives

Metallic and nonmetallic coatings, petroleum-base materials, volatile inhibitors and evaluation procedures for all are discussed.

"Rust Preventives," E J Colerick, Shell Oil Co, Lubrication Engineering, Aug 1958, 84 E Randolph St, Chicago 1.

Reinforced Epoxy with Metal Fiber

Two-part article discusses use of steel, aluminum and steel-and-aluminum metal metal fibers in epoxy resins for plastic tooling. Process, properties and characteristics, equipment, results of wear tests and actual production runs are given.

"Reinforcing Epoxy with Metal Fibers," A P Mazzucchelli, Bakeline Co, SPE Journal, Sept '58, 65 Prospect St, Stamford, Conn.

Specifications for Nuts

Reasons for use of separate specifications for nuts, rather than all-inclusive specifications for the fastener assembly, are given. Critical factors are discussed and suggestions for writing the specification are included.

"Why Nuts Should Have Their Own Specifications," J S Davey, Russell Birdsall and Ward Bolt & Nut Co, Industrial Fasteners, Vol 13, No 3, 1517 Terminal Tower, Cleveland 13.

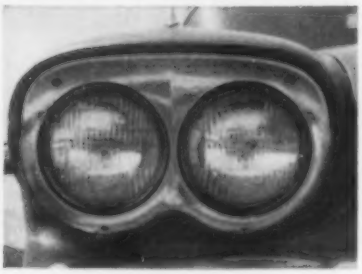
Equating Vibration Service Conditions with Testing Procedures

In devising suitable random vibration tests for hardware, problem arises of equating long-duration, low-intensity service effects with short-duration, high-intensity test procedures. A method of equivalence is presented, based on fatigue damage.

"Method of Equating Long-duration, Low-Intensity and Short-Duration, High-Intensity Random Vibration," A J Curtis, Hughes Aircraft Co, SAE Paper 830, 485 Lexington Ave, New York 17.

THIS IS GLASS

a bulletin of practical new ideas from Corning



On the beam

It looks as if the four-eyed automobile is here to stay. The reason?

The old style 7-inch lamp had two filaments and was a *compromise* design since *neither* high nor low beam operated at peak efficiency.

New style lamps are smaller (5¾") and are mounted two-to-the-fender. The outer light is a passing (low) beam, aimed just below and to the right of dead ahead. It also has an auxiliary high beam which is used with the high beam of the inner lamp. Net result: *More light* where you can use it . . . on the road and free of glare.

Though the lenses used in these lamps don't look complex, each is precision-made from heat-resistant glass. Pressed into the surface of every lens are some 100 prisms, each *held to* ±.1° in production.

There's also a glass parabolic reflector for each lens—the combination being a neat example of *mass* production of *precision* glass products. Also involved: Hermetic sealing of glass and metal parts.

Corning currently produces components for some 250 different sealed beam assemblies, with sizes ranging from 2 to 8 inches in diameter.

You may not need headlights, but if you have a problem involving light control, Corning may have the answer. And don't overlook the savings you can realize from mass production of precision parts. We'd like a chance to solve some of your problems.

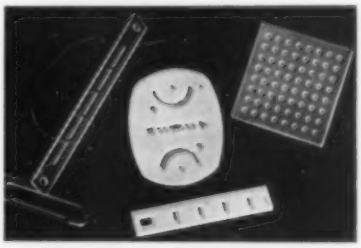
Wee

This 25 ml conical micro flask measures 75mm. in height. It has two necks, both ground to what is called a "standard taper," very accurate and smooth.

Such petite and precise PYREX brand glassware is fashioned from Corning's glass No. 7740. This glass is eminently practical in labs (and in many tough industrial applications) because it stands up to most acids and alkalies, doesn't cloud, even with distilled water. And it's bothered not a bit by high temperatures or thermal changes.

This microware flask is one of the more than 9,000 items (standard and custom) we make for labs. Much of it is highly intricate stuff that is hand-made by skilled lampworkers. The whole line is neatly detailed in a new, 358 page catalog, LG-1. If you're in a lab and haven't received your copy, send for one.

Also ask for Bulletin B-83, "Properties of Selected Commercial Glasses." All about 7740 and many other glasses; very good to have on file.



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We start with a photosensitive glass (one of a number of very *special* types from Corning). Using a photographic negative of the pattern you want and an ultraviolet source, we make a contact print on the glass. Then heat to convert exposed areas into etchable glass. Next, treat with acid to dissolve out the etchable image, leaving the pattern you want. Further processing converts to the form of FOTOFORM best suited to your final application.

What's FOTOFORM good for? Making *ultra*-precise mechanical and electrical parts.

Such as? Fine mesh (600 line) screens, brush holders for digital converters, various kinds of substrates, printed circuits, attenuator plates, dielectric spacers . . . and lots more.

Experience so far indicates that FOTOFORM makes feasible patterns and parts that would be *impossible* or *impractical* by other methods.

Added incentive: There's *no* need for costly dies and jigs and you *eliminate* grinding, cutting, and drilling.

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For more facts and figures ask for "New Developments in Corning FOTOFORM Glass." Check the coupon.

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Now available from Corning is a new, high-lead-content glass for use in Cerenkov counters. A crystal clear glass with a specific gravity of 4.63, it permits better energy resolution than any glass currently used with this type of spectrometer.

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NEWS FROM FLEXONICS

HOSE APPLICATION ENGINEERING

One of a series of reports on more effective use of flexible hose.

HOW TO DESIGN MOVING CONNECTIONS

. . . for conveying liquids and gases to get maximum service life from flexible metal hose

The secret of successful use of flexible metal hose for moving connections can be summed up quite simply in two important rules:

1. Do not torque the hose
2. Avoid sharp bends

By keeping these rules in mind, it is easy to design moving connections that will meet every requirement for effectiveness and long life.

Torque

A metal hose connector is subjected to torque either by twisting in installation or by twisting on flexure. Twisting in installation can usually be forestalled by specifying a union or a floating flange at one end of the hose assembly. Twisting on flexure can be prevented by designing the installation so that flexing takes place in *one plane*.

Figures 1 and 2 show commonly encountered cases of installations which cause torque in flexure and how they can be prevented.

Sharp Bends

A few of the many ways that metal hose connections can be subjected to sharp bends are shown in Figure 3 along with the recommended installation for the same type of motion. Bend radii should be governed by the metal hose manufacturer's specifications.

In some cases where design restrictions make the "right" installation impractical, a guard of interlocked hose over the connector will reduce the severity of bends and prolong hose life.

What Kind of Hose?

Selection of hose type and material should be made with the help of a Flexon Metal Hose Design Guide. This is a 36-page booklet that, for the first time, takes the mystery out of metal hose and presents authoritative, detailed information on such subjects as —fundamentals of metal hose . . . how to select metal hose . . . installation guides . . . typical examples of application problems . . . corrosion data . . . fitting data . . . plus complete specifications for all types of Flexon corrugated and convoluted hose.

You'll find the Flexon Metal Hose line to be the most complete offered by any manufacturer. And it is backed by manufacturing and application know-how second to none. This is evidenced by the Flexon Metal Hose Design Guide. Be sure and ask for a copy, today. There's no obligation.

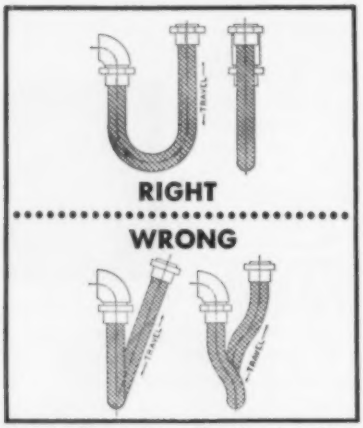


Fig. 1—Typical application in which twisting in flexure can be present and how to avoid it.

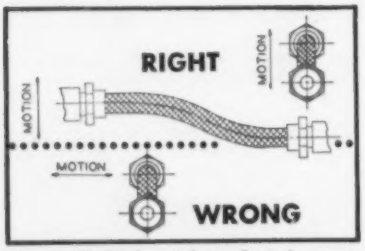
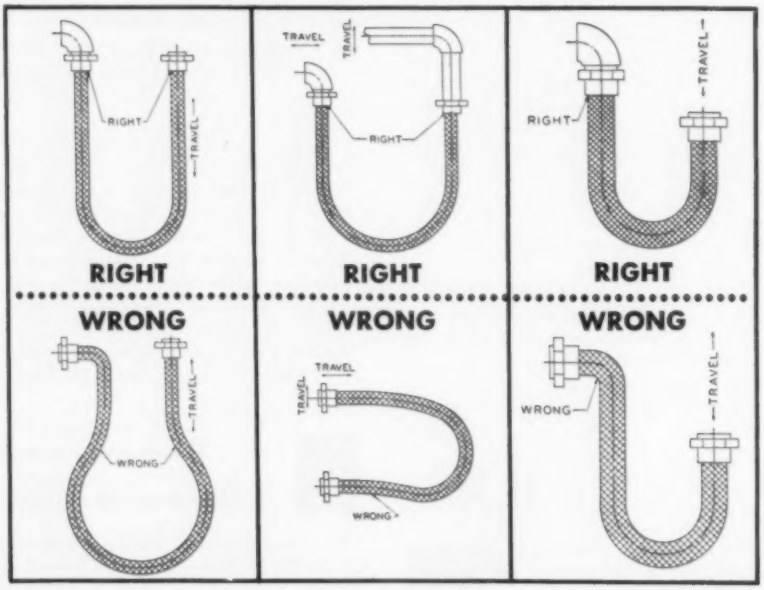


Fig. 2—If flexing takes place in more than one plane, the hose will be twisted in flexure.

Fig. 3—Typical examples of the type of connections in which recurring sharp bends occur and how they can be prevented.



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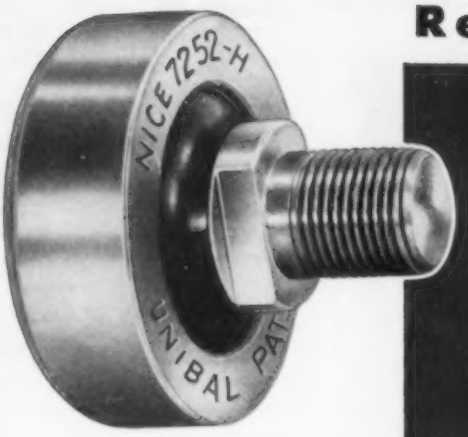

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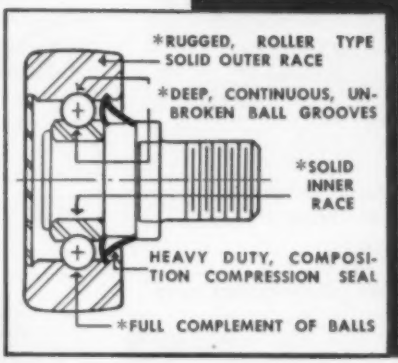
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*DEEP, CONTINUOUS, UNBROKEN BALL GROOVES
*SOLID INNER RACE
HEAVY DUTY, COMPOSITION COMPRESSION SEAL
*FULL COMPLEMENT OF BALLS

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NICE bearing No. 7252-H illustrates the ruggedness of the UNIBAL construction. The UNIBAL features of this plunger guide roller enable it to perform well under adverse conditions of heavy impact loading and a unique new composition seal design (patent applied for) effectively retains lubrication and excludes dust, dirt and moisture.

NICE ball bearings in this UNIBAL design are available in a wide range of sizes and types, with such features as extended races, snap rings, seals and shields. Your Inquiries are Invited.

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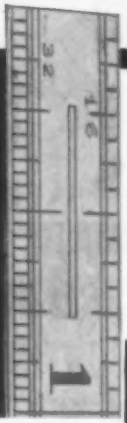

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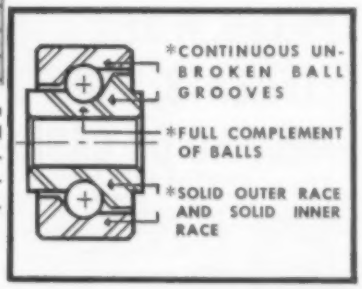

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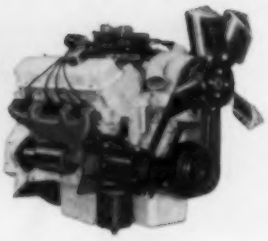

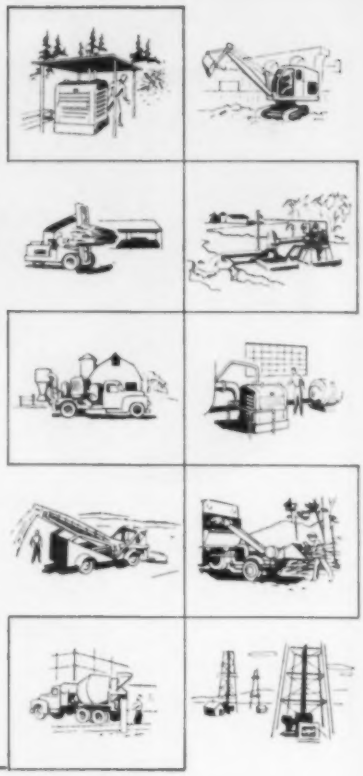

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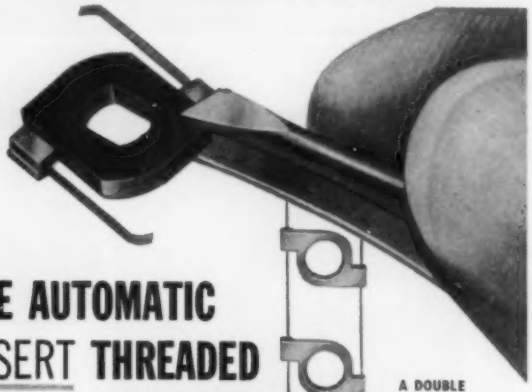

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NEW BOOKS

Development and Evaluation of Ceramic Coatings

S. SKLAREW, C. A. HAUCK, A. V. LEVY, *8½x 11, 98 pp, paperbound. Office of Technical Services, US Dept of Commerce, Washington 25, DC.*

How to take advantage of heat resistance of ceramic materials without paying penalty for their brittleness is a major problem of the Space Age. Among many solutions being investigated is use of reinforced ceramic coatings—refractory materials incorporating metal mesh and ceramic fibers to give them resistance to thermal shock and impact. This report gives first results of a continuing study, under Air Force sponsorship, aimed at finding the best combination of expanded metal, fibers, binders, and refractories for combustion-chamber linings and similar applications.

Permanent-magnet Handbook

EDITED BY CARL M. UNDERHILL. *Purchase through Crucible Steel Co. of America, Oliver Bldg., Mellon Square, Pittsburgh 22, Pa. Attention: Michael Stumm. Loose-leaf, 6x9, 380 pp. $10.*

This handbook is published by a single manufacturer but attempts to provide magnetic theory, design, measurements and material specifications for all products, competitive as well, where necessary to make the story complete.

The introduction provides some history of magnets and itemizes many applications. A chapter on design derives basic equations and establishes nomographic and graphical techniques

Continued on page 109

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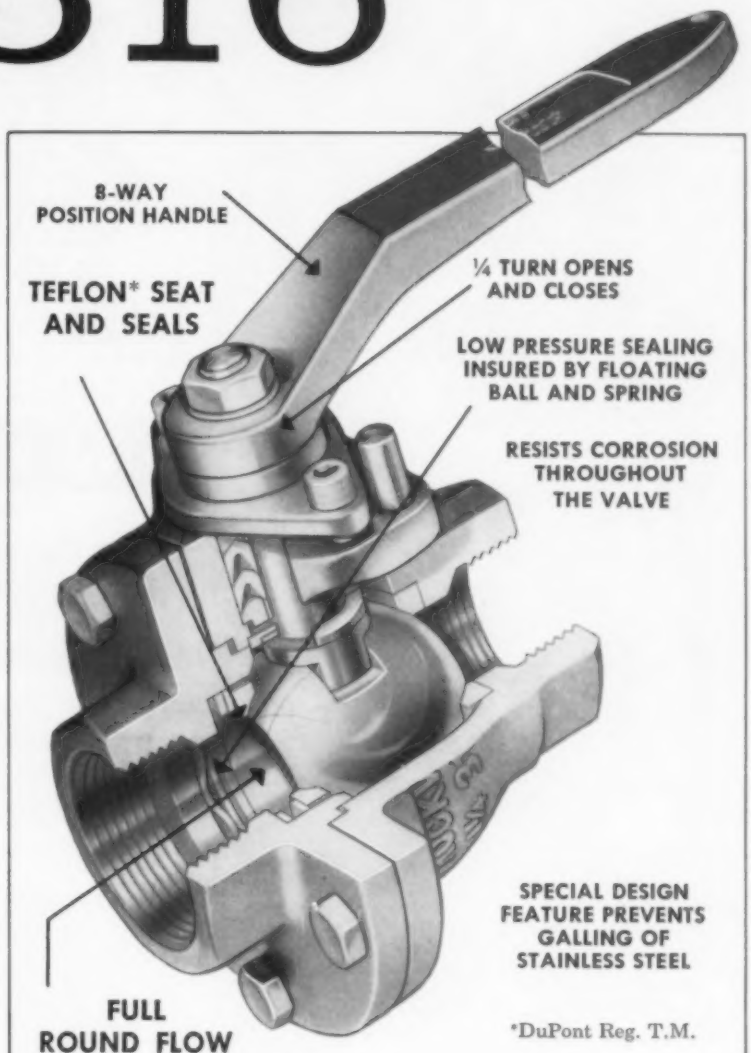
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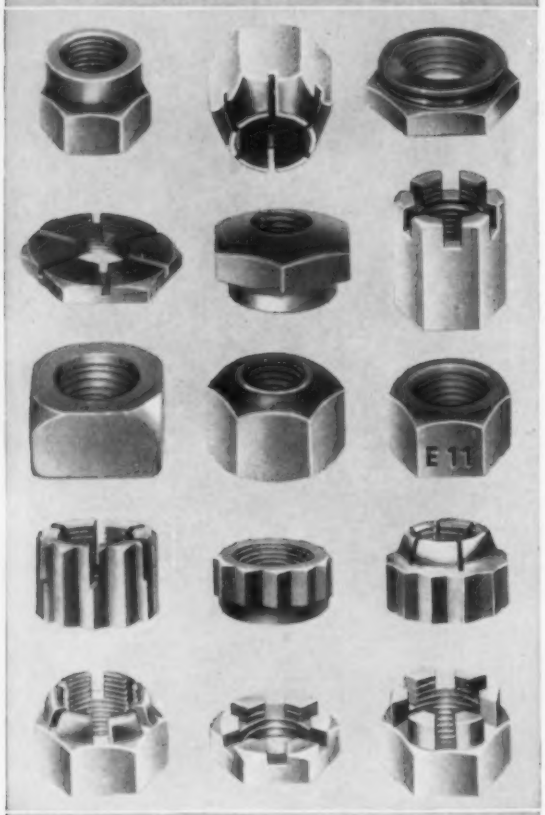

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to solve for field strength, coercive force, leakage, and other performance elements. Another chapter is devoted to measurements. The remaining chapters discuss the theory of ferromagnetism, electromagnetism, permanent metallurgy, Alnico, iron powder, manganese-bismuth, copper-nickel alloys, and ceramics. The technique of magnetization and demagnetization is also described.

The final chapter consists of 125 pages of plotted and tabulated magnetic and physical data of most known permanent magnetic materials. This includes a demagnetization curve with energy product B/H for each type. Also, information on density, thermal expansion, hardness, and method of manufacture.

Purchasers of the handbook are promised revisions to keep the book up to date.

Design of Die Castings

GUSTAV LIEBY *Published by American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill. 199 pp, 6 x 9. $8.*

This book, translated from the German, wastes little time in getting down to business. It methodically and completely covers all phases of die casting design: selection of materials, mechanical properties, including compression and elevated temperature properties, shape, wall thickness, tolerances, casting, trimming, coatings and finishes.

This book has two deficient points: dimensions in millimeters, though the more awkward units have been con-

(Continued on page 113)

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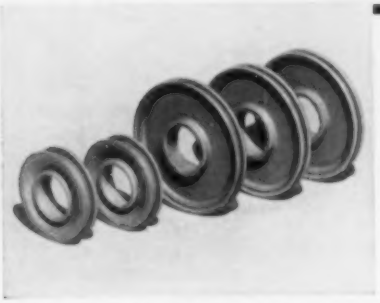

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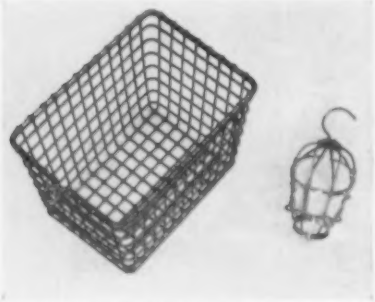

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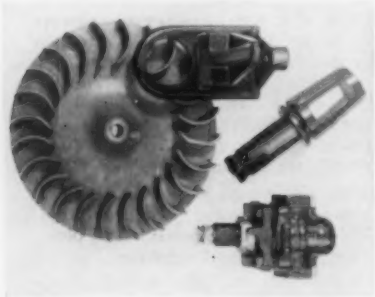

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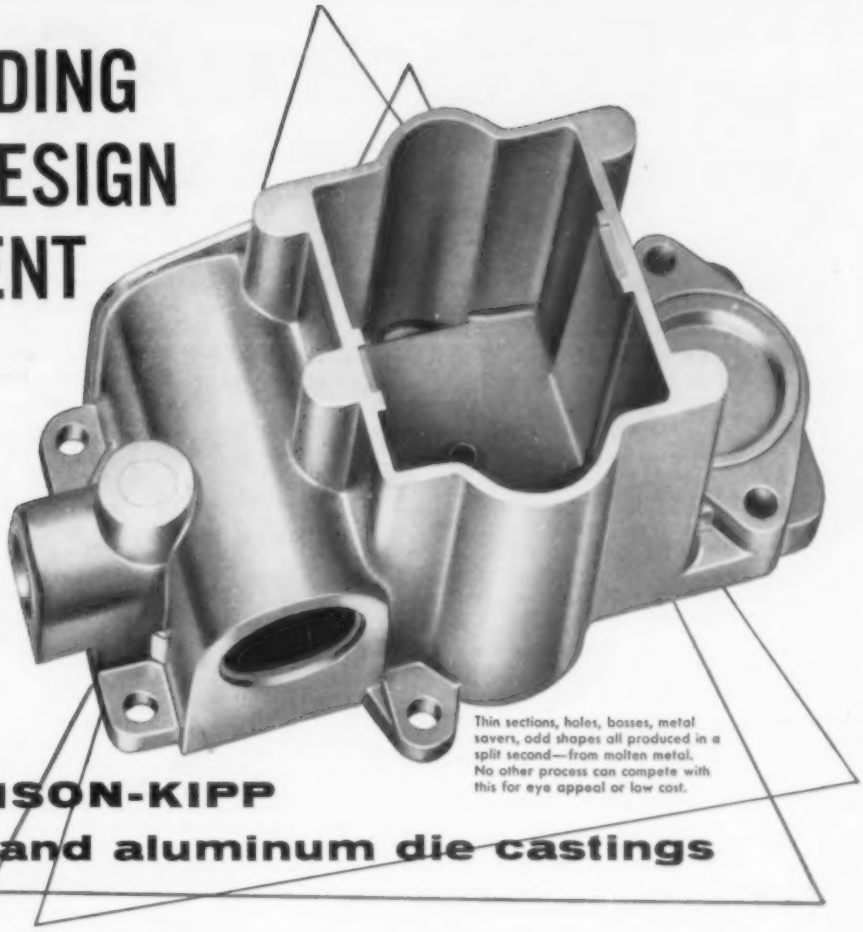

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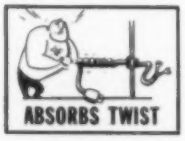

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verted; inconvenience because many diagrams are not on the same or facing page for handy reference. But for its excellent content this compact design guide should be forgiven for its minor faults and rather high price.

Mathematical Tables

HERBERT BRISTOL DWIGHT, *5½x8, paperbound, 220 pp. Published by Dover Publications, Inc, 920 Broadway, New York. $1.75.*

Printed on special paper that "will not discolor or become brittle with age," this low-cost edition of a book originally published by McGraw-Hill in 1941 has been streamlined in several ways and sports several additions, as well. It covers squares and cubes, all the usual trigonometric data and Bessel functions; omits only the tables in hundredths of degrees.

Modelmaking for Industrial Design

RALPH R. KNOBLAUGH. *Published by McGraw-Hill Book Co, 330 W 42nd St, New York 36. 7x10, 275 pp. $9.75.*

Both engineer and industrial designer can profit from this book on modelmaking. Drawings and sketches, no matter how detailed, cannot equal three-dimensional models for appearance or operational checking. The working of plaster is featured because it is suited to many model types. Working methods for plastics, metal and wood with simple hand tools and small power tools are also described. Layout, assembly, and paint finishing are detailed and recommendations for selection of tools and organizing the shop are given.

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Numerical Control of Machine Tools

How it works; where it's heading. Oct. 27, '58. *Circle E 45*

Optical Projectors

How projectors may be used in development, research and laboratory testing. Chart gives limitation and advantages of 30 conditions. Design Digest '58. *Circle E 44*

Three New Rigid Thermoplastics

Delrin, Lexan and Pro-fax are compared; curves and tables. Sept. 29, '58. *Circle E 43*

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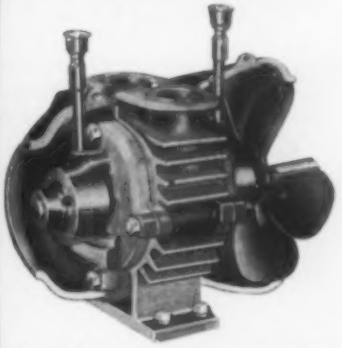

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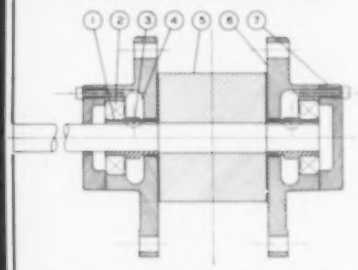

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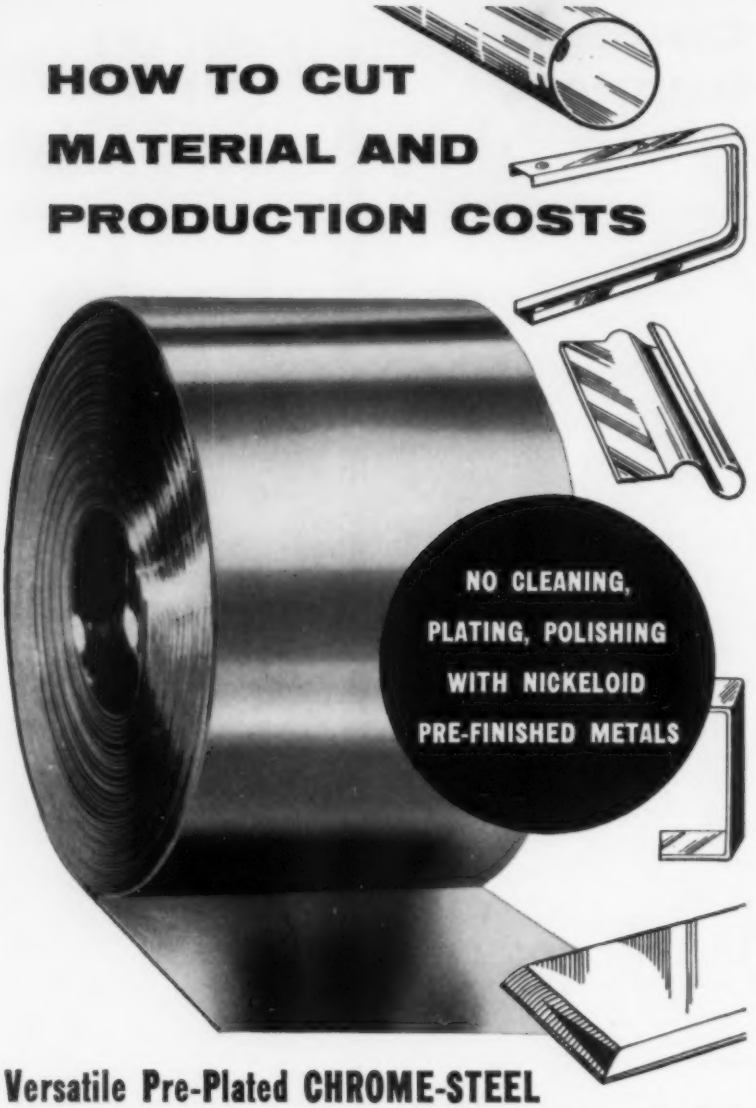

Versatile Pre-Plated CHROME-STEEL and NICKEL-STEEL Now Available in Three Grades

Cut costs! — Reduce production steps! The *need* was never greater; the *method* never surer than with Nickeloid chrome-steel and nickel-steel . . . now available in C-grade, *a new low-cost utility grade* for applications that don't require the quality of our A and B grades. These cost-cutting design materials are *pre-finished* — eliminate extra handling, cleaning, racking and polishing costs, plus actual plating costs. So versatile — adaptable to standard production methods, too! Their beautiful durable finishes can add so much in sales and utility value to your products at very low cost. Cut costs, reduce production steps with Nickeloid chrome-steel or nickel-steel — big 24" wide coils, sheets, strips; bright and satin finishes. Now save even more with new low-cost C-grade!

NICKELOID METALS SINCE 1888 N·M

Write For More Information

AMERICAN NICKELOID COMPANY

PERU 4, ILLINOIS

MILLS — Peru, Illinois and Walnutport, Pennsylvania

Sales Offices Throughout the U.S.A.

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ADVANTAGES OF FLEXIBLE SHAFTING

For Power Drive and Remote Control

by C. Hotchkiss, Jr.

Application Engineer,

Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative motion

2—eliminates exposed revolving parts

3—does not require accurate alignment

4—easy to install and maintain

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment, See example, figure 1, in which a 1¼ inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

Fig. 1

Relative Motion—Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾ inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Company.

Fig. 2

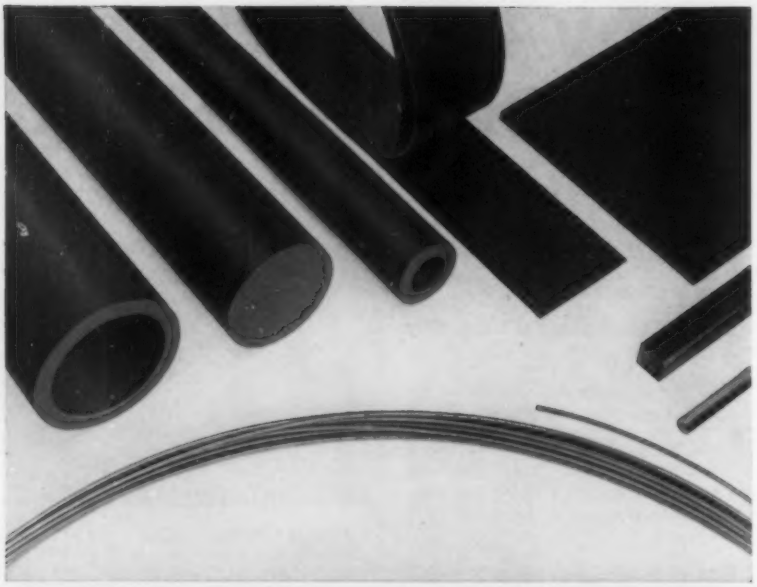
Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛ inch to 1¼ inches; for remote control applications in diameter sizes from ⅛ inch to 1⅝ inches. The 1¼ inch power drive shaft will transmit up to 10 HP while the 1⅝ inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering Bulletin 570.

STOW MANUFACTURING COMPANY

426 STATE STREET, BINGHAMTON, NEW YORK



NYLATRON® G S

Gives the property advantages of nylon, PLUS... improved mechanical characteristics:

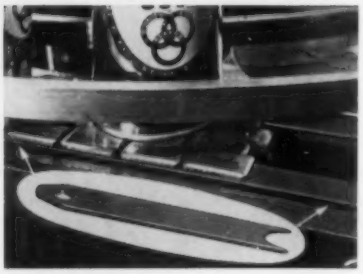
- Greater Rigidity—higher modulus of elasticity, less deformation under load.
- Higher Heat Distortion Temperatures—distortion temperatures 70% higher than nylon 101.
- Lower Thermal Expansion—coefficient approximately 60% of nylon 101.
- Low Surface Friction—can be used without lubrication.
- High Wear and Abrasion Resistance—can outlast, outperform metal.

NYLATRON GS, a molybdenum disulphide filled nylon*, is formulated to expand the field for nylon parts such as bearings, bushings, liners or other wear parts. Its superior mechanical and thermal characteristics coupled with the chemical and electrical properties of nylon result in a material with proven advantages. It is produced under controlled manufacturing standards to assure the ultimate in uniformity, quality and reliability.

Stock shapes of NYLATRON GS include rod, strip, tubing, tubular bar and plate in all standard sizes—for rapid, low-cost fabrication on standard metalworking tools. In addition, it is available in powder form for molding.

Polymer can also supply stock shapes of all commercial nylons on request.

Write today for detailed information about NYLATRON GS—or other nylon formulations to meet your specific requirements.



NYLATRON GS wear strips provide excellent wear cushion between metal bottling chain and conveyor stands. Due to inherent wear resistance and low surface friction, NYLATRON outwears metal strip while reducing wear on chain and stand.

*Patents applied for

THE POLYMER CORPORATION OF PENNA.
Reading, Pennsylvania
Export: POLYPENCO, INC., Reading, Pa., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

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F. J. Eberle, Business Mgr.

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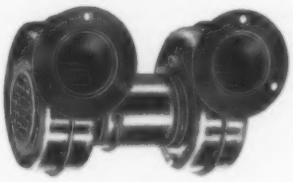
put HEINZE in your designs

HEINZE BLOWERS GIVE YOU THE AIR

QUIETLY
ECONOMICALLY
DEPENDABLY

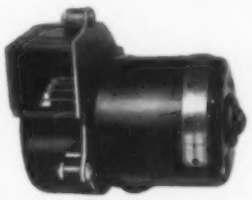
Y BLOWER

Single unit supplies 50 cfm, double unit 100 cfm — at 1650 rpm. Type Y 4 pole shaded pole induction motor. Rugged metal housing.



D BLOWER

Single unit delivers 55 cfm at 3200 rpm; double unit supplies 100 cfm at 3100 rpm. Type D 2 pole shaded pole induction motor. Strong metal housing.



D 2½ BLOWER

Single unit delivers 17 cfm (free air), double unit 34 cfm (free air) at 3100 rpm. Type D 2 pole shaded pole induction motor. Durable plastic housing.

DSH & YSH BLOWER-HEATERS

For warming and drying applications such as hot food vending machines, photographic dryers, etc. Heater can be thermostatically controlled. 55 cfm at 3000 rpm. Heater ratings from 200 to 1000 watts. 2 pole or 4 pole shaded pole induction motor.

Heinze Blowers are supplied as compact units with powerful sub-fractional horsepower motors for a wide variety of applications: photographic darkrooms; laboratories; kitchens; refrigeration and air conditioning units; cooling of electronic transmitter tubes; induction heaters; diathermy equipment; vending machines; and similar uses.

Blowers are available as single or double units — quiet, lightweight and durable. Standard models operate on 115V, AC, 60 cycle — but other voltages and frequencies may be supplied. Wide range of models and mountings allow speedy adaptation to your exact requirements. When you need dependable blowers — *put Heinze in your designs.*

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

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685 Lawrence St., Lowell, Mass.

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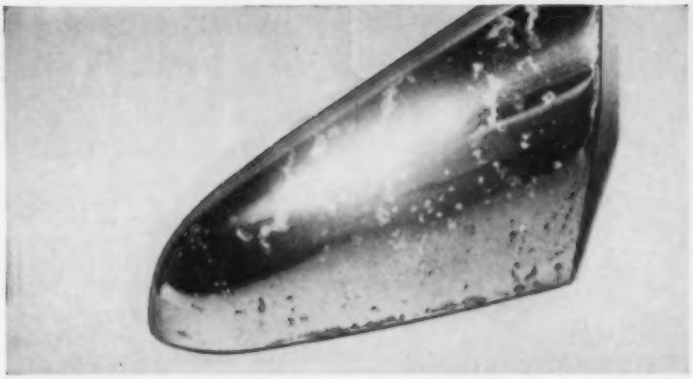
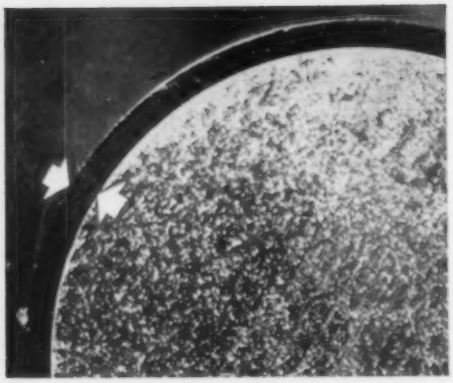
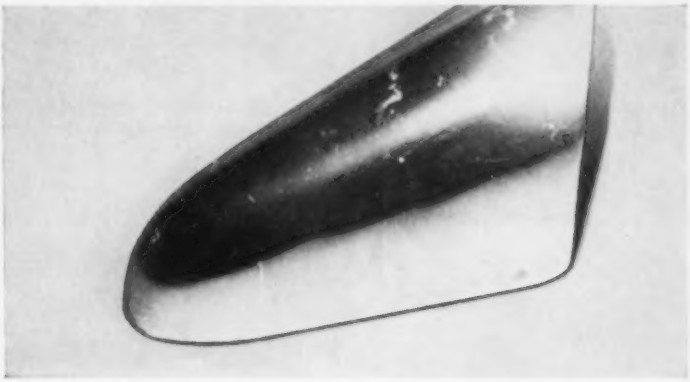
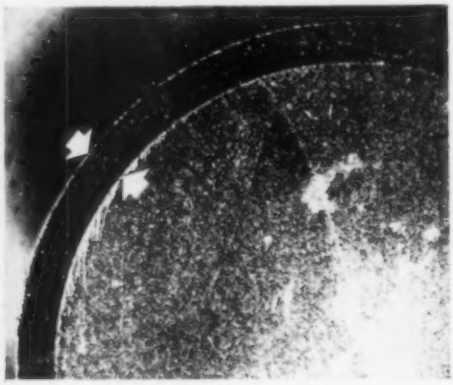


UNICHROME BRIGHT CRACK-FREE CHROMIUM MADE THIS DIFFERENCE IN PROTECTION. Photographs show results of 72 hour acetic acid salt spray test. Part at top was plated with ordinary chromium according to automotive manufacturer's specifications for copper, nickel, chromium finishing. Part at bottom had same copper and nickel deposits but Unichrome Crack-Free Chromium replaced the ordinary chromium, thus greatly increasing corrosion resistance.



UNICHROME SRHS® CHROMIUM MADE THIS DIFFERENCE IN THICKNESS. Enlarged cross sections of identical steel rods show ratio of thickness of plate from ordinary chromium solution (top) to thickness from SRHS Chromium Solution (bottom) . . . a much thicker deposit in the same plating time!





How to get more corrosion resistance from chromium plate

When consumers find fault with decorative chromium plate, it's generally due to early corrosion.

This trouble starts with pores and cracks that occur in all ordinary chromium in the range of thicknesses generally used for decorative plating. Road chemicals, salt atmosphere and fumes find a path right down to base metal. Corrosion starts. As corrosion increases, finish failure progresses, allowing still more corrosion.

But you can stop this at the source.

THICKER, CRACK-FREE CHROMIUM

Chromium itself is passive. It doesn't corrode. Eliminate pores and overcome its cracking and you greatly improve its corrosion *protection*. Pores are eliminated by thicker plating. To overcome cracking, use the Unichrome Bright *Crack-Free* Chromium Process. This deposit is free from corrosion-admitting cracks. It has already been used in automotive production for a year.

MINIMIZE PRODUCTION PROBLEMS

Unichrome *Crack-Free* Chromium is far superior to ordinary chromium not only in protection, but also in operating advantages. The solution is self-regulating. It offers improved throwing power, also better coverage — even over passive nickel.

TO PLATE THICKER CHROMIUM

For those who desire thicker deposits but do not require freedom from cracking, other Unichrome self-regulating processes offer distinct advantages. They plate up to 80% faster than ordinary chromium plating processes. They cover parts with less dulling or burning, are less susceptible to clouding due to current interruption. Control is simplified by their self-regulating features.

Whichever process is best for your products, Metal & Thermit has over 30 years of service experience to help you make it work. Call in an M&T plating engineer to survey your requirements, tell you what's needed for the results you want. Or, send for Bulletins.

METAL & THERMIT
CORPORATION

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26—Heavy-duty Rod Retainer

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23—Size 10 Servomotor

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CITY ..... ZONE ..... STATE .....

CO. NAME ..... PRODUCT(S) MFGRD. .....

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☐ Bill Me

☐ Check Here For 2 Yrs. @ $8.00

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17—Axial Piston Pumps, Motors
18—Tubing and Tap Valves
19—4-way Dual-seal Valve
21—¼-in. Hydraulic Valve
25—3-way Solenoid, Pilot Valves

* Where advertisements list more than one product, indicate in box on card the key number and specific products in which you are interested. Also, a few ads cannot be keyed. When this occurs, please write advertiser's name on line at bottom of card.

CATALOGS AND BULLETINS OFFERED IN THIS ISSUE

GENERAL ENGINEERING

47—Stainless Steel Thermometers, 8 pp, W C Dillon Co, Inc.
59—Cable Caliper, Zippertubing Co.

METALS AND ALLOYS

29—Iron Powders, 52 pp, Republic Steel Corp.
44—Heat, Corrosion-, Oxidation-Resistant Alloy, 4 pp, Hoskins Mfg Co.
48—Steel Castings, 6 and 4 pp, Farrell-Cheek Steel Co.
57—Tool Steels, Vulcan-Kidd Steel Div, H K Porter Co, Inc.

NON-METALLIC MATERIALS, FINISHES

56—Nickel Alloy Coating, 12 pp, General American Transportation Corp.

POWER TRANSMISSION

53—Magnetic Friction Clutches, Brakes, 8 pp, Dynamic Div, Eaton Mfg Co.

MECHANICAL PARTS

40—Compensated Conveyor Belt, 12 pp, Raybestos-Manhattan, Inc.
43—Metal Balls, 4 pp, Stom Steel Ball Co.
52—Dials, Panels, Nameplates, 6 pp, US Radium Corp.
55—Plastic Core Belting, 4 pp, Graton & Knight Co, Inc.

ELECTRICAL, ELECTRONIC COMPONENTS

31—Transformers, 32 pp, Chicago Standard Transformer Corp.
39—Small Panel Instruments, 6 pp, General Electric Co.
45—Microminiature Relays, 2 pp, Electronics Div, Iron Fireman Mfg Co.
46—Servomount Potentiometers, 4 pp, Helipot Div, Beckman Instruments
49—Electrical Control Cables, 4 pp, Triangle Conduit & Cable Co.
51—Aircraft and Missile Accessories, 4 pp, Barber-Colman Co.
54—Electronic Go-No-Go Gage, 4 pp, Computer Measurements Corp.
58—Miniature Rheostat, 2 pp, Ohmite Mfg Co.

HYDRAULIC, PNEUMATIC EQUIPMENT

30—Thermocouple Assemblies, 36 pp, Conax Corp.
32—Rotary Pumps, 12 pp, Roper Hydraulics, Inc.
33—Ceramic Insulated Thermocouples, 8 pp, Aero Research Instrument Co.
34—Small, Cold-drawn Tubing, 12 pp, Superior Tube Co.
35—Steel Tubing, 8 pp, Ohio Seamless Tube Div, Copperweld Steel Co.
36—Special-purpose Alloys for Welded Tubing, 8 pp, Alloy Tube Div, Carpenter Steel Co.
37—Superalloy and Reactive Metal Tubing, 44 pp, Damascus Tube Co.
38—Small Alloy Tubing, 12 pp, Precision Tube Co.
41—Remotely-operated Relief Valves, 1 p, Fluid Controls, Inc.
42—Central Power Lubrication Systems, 4 pp, Lincoln Engineering Co.
50—Pneumatic Vibration Isolation Systems, 4 pp, Walter Kidde & Co.

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FREE REPRINTS
E31 E35 E36 E37 E38 E39 E40
E41 E42 E43 E44 E45 E46

* Item No.	PRODUCT

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205	217	229	241	253	265	277
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206	218	230	242	254	266	278
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207	219	231	243	255	267	279
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208	220	232	244	256	268	280
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209	221	233	245	257	269	281
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288

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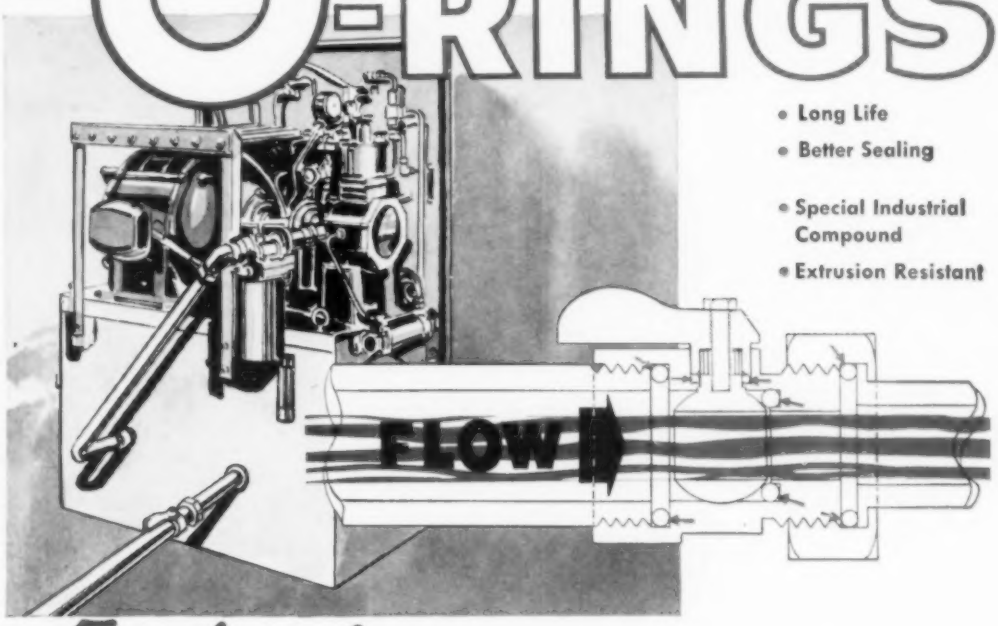
FACTS for FILING on O-RINGS



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Minnesota Rubber Company's latest advance in rubber processing is a new, automated method for producing O-rings called MINJECTO. MinJecto makes it possible to produce better O-rings more economically than ever before. You'll be surprised at the savings which we pass on to you.

Besides saving you money MinJecto O-rings give longer service life because this exclusive method of injection molding gives a denser product that wears better and is more resistant to extrusion under pressure than O-rings produced in other ways.

MinJecto O-rings are also flash-free, tolerances are closer and sealing is better.

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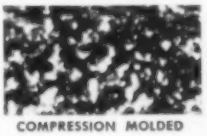
These O-rings are made out of standard compound 366Y. This 70 durometer compound has been developed by Minnesota Rubber to fit almost every industrial application imaginable. It is highly resistant to chemicals and oils, has outstanding temperature characteristics, and high tensile strength. If you want the finest possible O-ring at the lowest possible cost, Minnesota Rubber MinJecto O-rings are what you are looking for.



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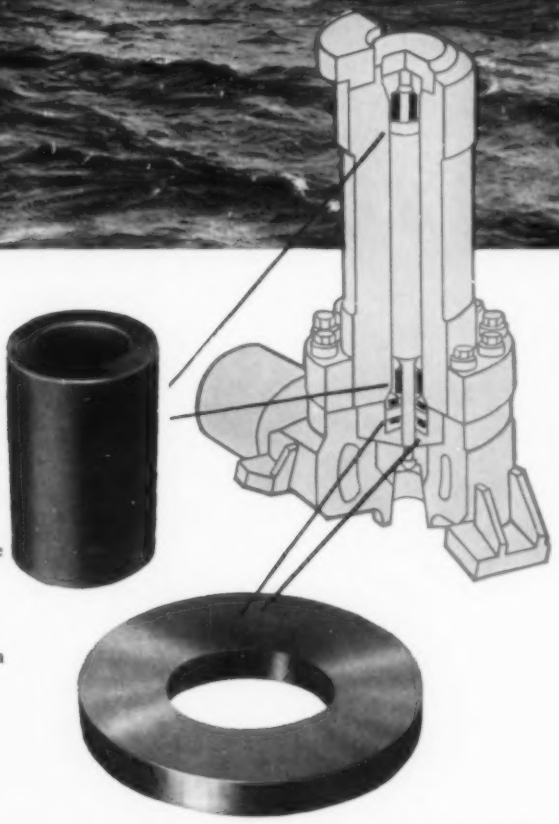
GRAPHITAR® BEARINGS SUCCESSFULLY WITHSTAND 50,000 MILE TEST IN ATOMIC POWERED SUBMARINE U.S.S. NAUTILUS

Working closely with the Atomic Energy Commission, the Westinghouse Electric Corporation designed and built the power plant for the NAUTILUS, first atomic-powered submarine. The soundness of every engineering principle, every individual part—including the GRAPHITAR pump bearings—has now been proved by the more than 50,000 miles the submarine has steamed, approximately half was submerged. These Westinghouse-designed pumps are hermetically sealed within the integrated pump and drive motor. All leakage past the pump seal is contained within the flooded motor while the purely electrical elements are contained in "cans" to exclude the water.



The GRAPHITAR pump bearings in the power reactor of the Nautilus have withstood high speeds, extreme temperatures, and great pressures, and have come through this test-period with a perfect performance record . . . their only lubricant, radioactive hot water!

This same GRAPHITAR that has proved its ability to help harness the power of the atom is available for use in performing equally tough jobs in your product, too . . . why not get full information today.

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THE UNITED STATES GRAPHITE COMPANY

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